FIELD & OFFICE
STANDARDS

MONTANA
STATE HIGHWAY COMMISSION
HELENA MONTANA

INDEX

Note:
First three numbers refer to sheet number, remaining letters and numbers refer to standard numbers.

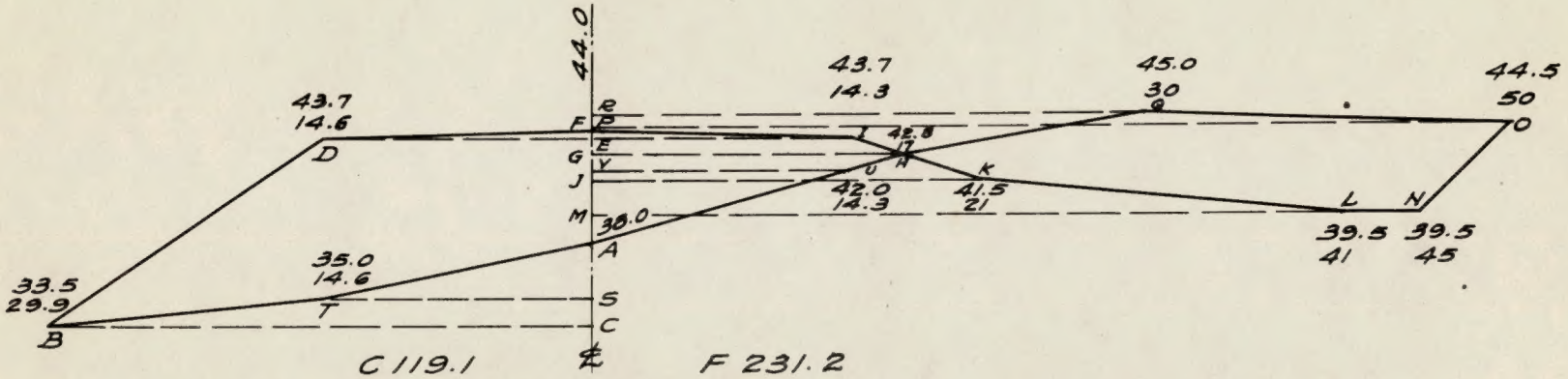
INDEX

STANDARD FOR STAKING NOTES & COMPUTING END AREAS

Rotchford – Inst. Iseminger – Rod Dorrington – Tape Jones – Axe

6/15/37
Clear - Warm

Sta.	Sub-Grade +	Hi.	Grade Rod	Super –	Elevation Shoulders Lt.	Elevation Shoulders Rt.	
B.M.	9.16	46.00			2036.84		Spike in 12" Tamarack 60' Lt. of Sta. 380+60
							32.2 33.5 35.0 38.0 42.0 42.8 45.0 44.5 44.7
							-10.2 -8.7 -6.0 -1.7 -0.9 C5.0 C0.7
584	44.00		2.0		℄		13.8 12.5 11.0 8.0 4.0 3.2 1.0 1.5 1.3
			2.5 2.3		14.6	14.3	35 29.9 14.6 14.3 17 30 50 60
			4.5		21		
			6.5		41-45		



The starting point is determined as follows:–

A. Where the area crosses center-line, start with the lower of the two center-line points.

B. Where the area does not cross center line, start with the naught naught point closest to center line.

In going around the areas, proceed counter clockwise on the right of center-line & clockwise on the left.

This method deals entirely with triangles & trapezoids, the horizontal distances forming the bases & the vertical distances forming the altitudes. One side of each triangle or trapezoid is formed by a vertical distance (altitude) on center-line. The altitude is found by subtracting the elevations involved in going from one point to another. The horizontal distances are read direct, the altitude being multiplied by each of the two. In going from a higher point to a lower point the triangle or trapezoid is a minus quantity & vice versa the quantity is plus. When one of the two points is on center-line the figure is a triangle, otherwise it is a trapezoid.

The formula for computing the area of any triangle or trapezoid is the altitude multiplied by the base or sum of the bases divided by two. This division is done last.

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CUT AREA

(42.8-41.5)x(17.0+21.0) = 1.3x38.0 = -49.40
area of trapezoid GJKH

(41.5-39.5)x(21.0+41.0) = 2.0x62.0 = -124.00
area of trapezoid JMLK

(44.5-39.5)x(45.0+50.0) = 5.0x95.0 = +475.00
area of trapezoid PMNO

(45.0-44.5)x(50.0+30.0) = 0.5x80.0 = +40.00
area of trapezoid EPOQ

(45.0-42.8)x(30.0+17.0) = 2.2x47.0 = -103.40
area of trapezoid BGHQ

Total Quantities +515.00
Total Quantities -276.80
238.20

238.20 ÷ 2 = 119.10 square feet
Cut area of figure HKLNOQ

FILL AREA

(Left of center line).

(38.0-35.0)x(00.0+14.6) = 3.0x14.6 = -43.80
area of triangle AST

(35.0-33.5)x(14.6+29.9) = 1.5x44.5 = -66.75
area of trapezoid SCBT

(43.7-33.5)x(29.9+14.6) = 10.2x44.5 = +453.90
area of trapezoid ECBD

(44.0-43.7)x(14.6+00.0) = 0.3x14.6 = +4.38
area of triangle FED

(Right of center line).

(42.0-38.0)x(00.0+14.3) = 4.0x14.3 = +57.20
area of triangle VAU

(42.8-42.0)x(14.3+17.0) = 0.8x31.3 = +25.04
area of trapezoid GVUH

(43.7-42.8)x(17.0+14.3) = 0.9x31.3 = +28.17
area of trapezoid EGHI

(44.0-43.7)x(14.3+00.0) = 0.3x14.3 = +4.29
area of triangle FEI

Total Quantities +572.98
Total Quantities -110.55
462.43

462.43 ÷ 2 = 231.215 square feet
Fill area of figure ATBDFIHU

CALCULATOR MACHINE METHOD COMPUTED WITH AN EIGHT ROW KEYBOARD
(All dials and the rows on the keyboard are numbered from the right to the left)

Turn into the upper dials 3 to 1 the elevation of the starting point as previously determined. In computing the area of the fill (ATBDFIHU) this figure would be 38.0. Establish two decimal points on the keyboard for the distances. In this instance the decimal points would be between rows 2 and 1 and between rows 7 and 6. Then the decimal points on the lower dials would be between dials 3 and 2 and between dials 8 and 7. The fill area either left or right of center-line can now be computed.

1. Starting on the left and proceeding clockwise, set the distance 14.6 around one of the keyboard decimals, say the one on the left side of the machine. Keyboard reads 14.60000.0. Change upper dials to read 35.0, the elevation at 14.6. Lower dials read (dials 11 to 1) 9956.20000.00 and the area of the triangle AST has been subtracted, always bearing in mind the fact that the final answer will be divided by 2.

2. Set 29.9 around the decimal point established on the right of the keyboard. Keyboard reads 14.60029.9. Change upper dials to read 33.5, the elevation at 29.9. Lower dials read (dials 11 to 1)

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204-A5

9934.29955.15 and the area of the trapezoid SCBT has been subtracted.

3. The next clockwise point is at 14.6 which is the number on the left of the machine. Therefore there is no change in the keyboard and it still reads 14.60029.9. Change upper dials to read 43.7, the elevation at 14.6 on the typical section or templet. Lower dials read (dials 10 to 1) 083.22260.13 and the area of the trapezoid ECBD has been added. It may be that a 1 or a 9 will appear in lower dial 12 or 13, depending upon the type of machine used or the manner in which the elevation 33.5 is changed to 43.7, but in any event disregard it.

Note: It is now obvious that the distances placed on the keyboard alternate from the left to the right of the keyboard, and that every distance is multiplied by the difference in elevation involved in going from one point to another. Therefore each distance is always multiplied by two figures, one when going to the distance and one when leaving the distance.

4. The next point is at center-line. Therefore clear the right side of the keyboard. Keyboard reads 14.60000.0. Change upper dials to read 44.0, the elevation at 0.0. Lower dials read (dials 10 to 1) 087.60260.13 and the triangle FED has been added.

5. Clear the left side of the keyboard. Keyboard reads 00.00000.0. Change upper dials to read 38.0. Lower dials will not change and the area to the right of center-line can now be computed.

6. Proceeding counter clockwise, set 14.3 on the left side of the keyboard. Keyboard reads 14.30000.0. Change upper dials to 42.0. Lower dials read 144.80260.13 and the triangle VAU has been added.

7. Set 17.0 on the right side of the keyboard. Keyboard reads 14.30017.0. Change upper dials to read 42.8. Lower dials read 156.24273.73 and the trapezoid GVUH has been added.

8. The next counter-clockwise point is at 14.3, so the keyboard reading remains 14.30017.0. Change upper dials to 43.7, lower dials read 169.11289.03, and the trapezoid EGHI has been added.

9. Clear the right side of the keyboard. Keyboard reads 14.30000.0. Change upper dials to read 44.0. Lower dials read 173.40289.03 and triangle FEI has been added.

10. Clear the keyboard. Considering the figure in the lower dials, 173.40289.03, as two separate answers, 173.40 and 289.03, add the two together. The result is 462.43, which number divided by 2 gives the fill area 231.215 square feet, figure ATBDFIHU.

1. In computing the cut area, turn 42.8 into the upper dials and set 17.0, the starting point and 21.0, the next counter clockwise point, on the keyboard. Keyboard reads 21.00017.0. Change upper dials to 41.5. Lower dials read 99972.69977.90 and the trapezoid GJKH has been subtracted.

2. Set 41.0 on the right of the keyboard. Keyboard reads 21.00041.0. Change upper dials to 39.5. Lower dials read 99930.69895.90 and the trapezoid JMLK has been subtracted.

3. Set 45.0 on the left of the keyboard. Keyboard reads 45.00041.0. 45.0 is the same elevation (39.5) as 41.0 so the upper dials do not change and lower dials remain 99930.69895.90.

4. Set 50.0 on the right of the keyboard. Keyboard reads 45.00050.0. Change upper dials to 44.5. Lower dials read 155.70145.90 and the trapezoid PMNO has been added.

5. Set 30.0 on the left of the keyboard. Keyboard reads 30.00050.0. Change upper dials to 45.0. Lower dials read 170.70170.90 and the trapezoid RPOQ has been added.

6. Set 17.0 on the right of the keyboard. Keyboard reads 30.00017.0. Change upper dials to 42.8. Lower dials read 104.70133.50 and the trapezoid RGHQ has been subtracted.

7. Clear the keyboard. Set 104.70 on the right side of the keyboard rows 5 to 1. Keyboard reads 000104.70. Add once with the carriage in the first position and subtract once with the carriage in the sixth position. Lower dials read (dials 5 to 1) 238.20. Divide mentally by 2 and the answer is 119.10, the cut area figure HKLNOQ.

GENERAL NOTES

There are several contingencies which should be considered when using the machine method, depending upon the type of machine, the number of rows on the keyboard, the farthest distance used, and the size of the areas. These contingencies may cause errors and so will be considered.

1. There are so many different types and makes of calculators being used that no attempt will be made to follow every step on each machine, but it is suggested that an operator, when following the examples, note the unnecessary numbers which appear to the left on the lower dial (step #3 computing the fill area and step #4 computing the cut area) so that error will not be made by incorporating such numbers in the final answers.

2. When using an eight row keyboard with distances not exceeding 99.9 feet, error may be made (if the final area is 500.00 or more square feet) by the area on the right of the lower dials running into the area on the left when the area on the right becomes too large. However an error of this kind will be at least 500.00 square feet in the final area and by observation can be seen when it appears on the machine. When using a ten row keyboard, the same thing may happen if the final area is more than 5000.00 square feet.

3. When the area is too large to work on your machine, split the area into enough parts so that it may be worked.

4. If the area extends past 100.0 feet, out from center-line, and there is therefore not enough rows on the keyboard (applicable to an eight row keyboard), subtract some constant from the distance on each rod reading and proceed as usual.

5. If on some area there is doubt, check it by longhand and the operator will soon become familiar with any machine errors.

6. If it is desired to figure exceedingly large areas (applicable particularly to overhaul) two machines may be used at the same time.

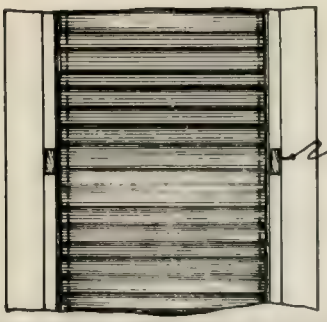
MONTANA STATE HIGHWAY COMMISSION

APPROVED JUN 1, 1946
[signature]
ADMINISTRATIVE AID

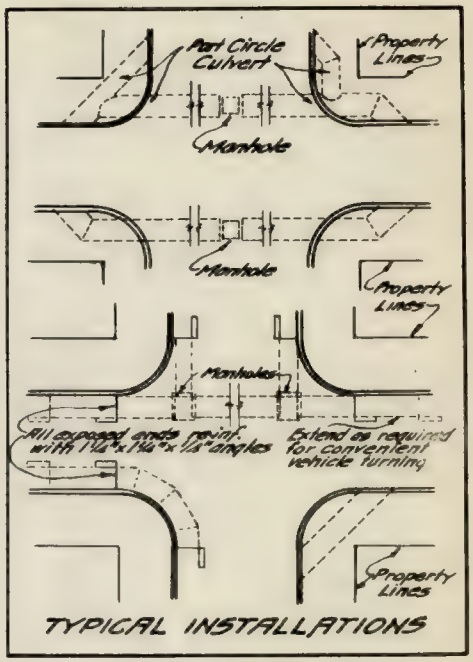
206-47

PART CIRCLE

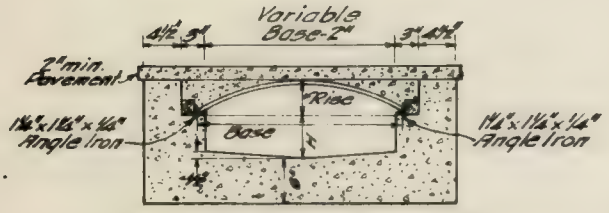
CORRUGATED METAL CULVERTS



TOP VIEW BEFORE GROUTING

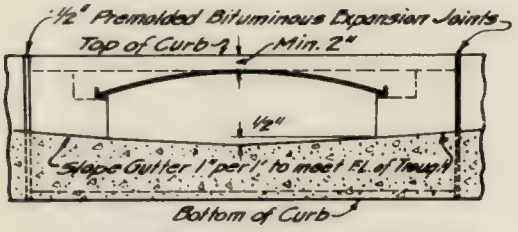


TYPICAL INSTALLATIONS



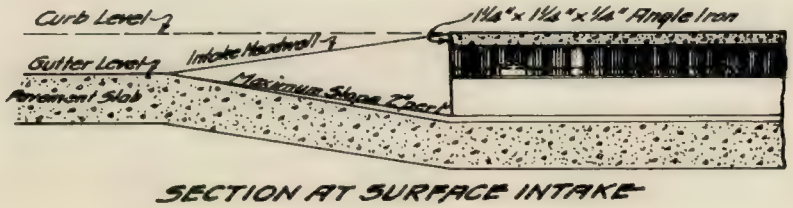
SECTION AFTER PAVING

Expansion Joints between the Concrete Trough and the pavement or curb are to be provided as required for the particular case.



CURB INTAKE

Note: Where pavement or sidewalk is not built over Part Circle Culvert a minimum of 6" dirt cover is required.



SECTION AT SURFACE INTAKE

In special cases shallow Standard Drop Inlets or Curb Inlets may be used at the intake end of Part Circle Culverts.
Special Design for gutter grades greater than 2 %.

APPROVED JUN. 1, 1946
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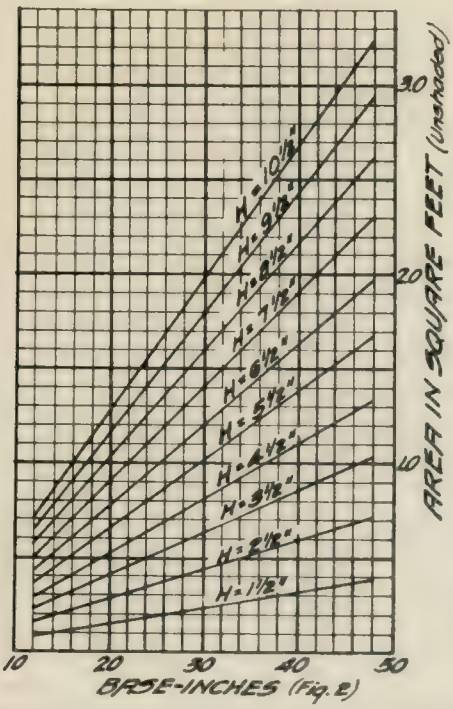
Montana State Highway Commission.

SIZES OF
PART CIRCLE CORRUGATED METAL CULVERTS



EXAMPLE

Given: Required waterway area (from drainage tables) = 1 square foot.

To Find: Part Circle Culvert and concrete trough requiring the least headroom (assuming 18" base).

From Table - Sizes of Part Circle Culverts - opposite 18" Base are Rises of 2½; 3¾; etc.

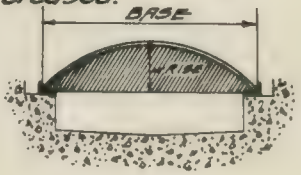
From Fig. 1 - 2½" Rise (interpolated) - 18" Base Area = 0.13 sq. ft. 1.00 - 0.13 = 0.87 sq. ft.

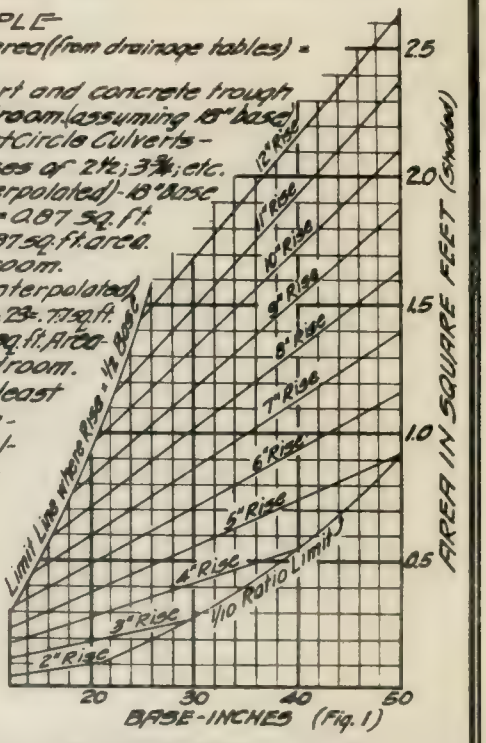
From Fig. 2 - 18" Base - 0.87 sq. ft. area. H = 8" - 8" + 2½" = 10½" Headroom.

From Fig. 1. - 3¾" Rise (interpolated) 18" Base - Area = 23 sq. ft. - 1.00 - 23 = .77 sq. ft.

From Fig. 2 - 18" Base - 0.77 sq. ft. Area - H = 7 - 7 + 3¾ = 10¾ Headroom.

Therefore: 10½" is the least headroom for an 18" Base - If less headroom is available the Base must be increased.





SIZES OF PART CIRCLE CORRUGATED METAL CULVERTS

GAUGE	WEIGHT PER FOOT																												
12	5.4	5.7	6.0	6.4	6.7	7.1	7.4	8.1	8.5	9.2	9.9	10.7	10.3	11.5	11.6	11.9	12.5	12.7	13.4	13.8	14.1	14.5	14.9	15.4	16.2	17.0	18.9	18.9	21.3	21.9	22.6	23.4
10	6.9	7.2	7.6	8.1	8.5	9.1	9.5	10.3	10.8	11.8	12.7	13.6	13.0	14.4	14.8	15.2	16.0	16.2	17.1	17.6	18.1	18.4	19.0	19.6	20.7	21.6	24.2	24.2	25.3	27.2	27.9	28.8	29.4
8	8.4	8.8	9.2	9.9	10.3	11.0	11.6	12.5	13.2	14.3	15.4	16.5	16.8	17.5	18.0	18.5	19.4	19.7	20.8	21.4	22.0	22.4	23.1	23.9	25.2	26.5	29.4	30.6	33.1	34.0	35.1	36.5	

BASE INCHES	RISE - INCHES																												
12	2	2½	3½	4⅛	4⅝	5⅛	5⅝																						
14				2¼	3¼	4⅛	4¾	5½	6¼	7																			
16							5⅛	4¾	5⅜	6½	7⅜																		
18								2½	3⅜	5½	6⅜	7½	7½	8¼	8¾					12 GA. MIN.									
20									2⅜	5½	6¼	7	7⅜	8	8⅝	9⅛	9⅜												
22										5¼	5⅜	5⅝	6⅜	7⅛	7⅝	8⅛	8¼	9½	10	10½	10⅝								
24												5⅛	5	5¾	6⅜	7⅛	7¼	8⅜	8¾	9¾	10⅛	10⅝	11¼						
26														3¼	4¼	6	6½	7⅛	8¼	9	9¼	9⅜	10½	11⅝	12⅜				
28																3½	4¼	6⅛	7	7⅛	8¼	9	9⅜	10⅜	11¾				
30																		5⅛	5	6¼	6⅜	7¾	8½	10	11	13½	14⅜	10 GA. MIN.	
32																				4¼	5⅜	7⅛	8⅜	10	12¼	13⅜			
34																						5	7½	8¾	11⅜	13⅛	15	15¾	
36																							5	7⅛	10⅜	12¼	14⅜	15⅜	16⅜	
42																									5⅜	8½	11¼	12¼	13⅛	17⅜
48																											6⅜	9⅜	14⅜	

12 GA. MIN. — 0 GA. MIN. — 10 GA. MIN.

NOTES

Part Circle Culvert is made in sheets 25½" long which when lapped make a length of 2'. The sheets are held in place by the pavement and are not fastened together.

Specifications for material for Part Circle Corrugated Metal Culverts are the same as for Corrugated Metal Culverts except for Minimum Gauge which is as shown in the above table.

Angle joints to be fabricated by welding and areas from which the spelter coat has been removed by welding operations shall be given a heavy coat of asphalt paint.

APPROVED JUN. 1, 1946
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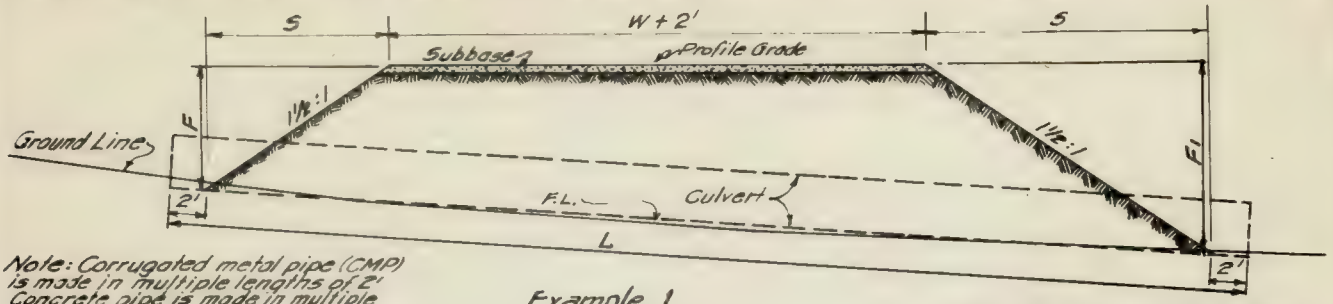
STANDARD METHOD OF DETERMINING CULVERT LENGTHS

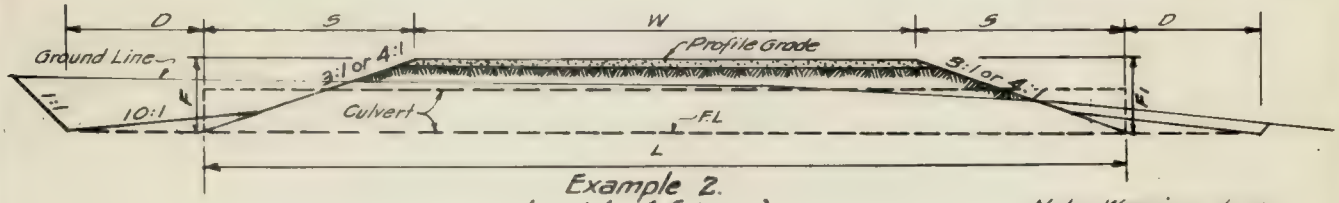


Note: Corrugated metal pipe (CMP) is made in multiple lengths of 2'. Concrete pipe is made in multiple lengths of 2'. Thus if 45' of pipe is required, 46' of CMP or 46' of concrete pipe would be used.

Example 1.

$$L = (W+2) + 1\tfrac{1}{2}(F+F_1) + 4$$

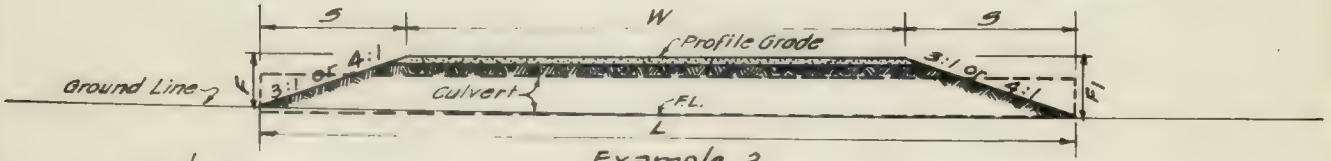
Note: All example illustrations are for 24 ft. finished roadway but the method of determining culvert lengths for other types is identical.



Example 2.

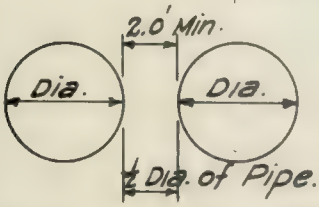
$$L = W + 4(F+F_1)$$

Note: Warping slope in to shorten culvert length required, is prohibited.



Example 3.

$$L = W + 4(F+F_1)$$



Spacing of Multiple pipes - The clearance between adjacent pipes should be a minimum of 2' or ½ Dia.

W. = Normal width of roadway at profile grade. Widened 1' on each side on fills over 5' in height with 1½:1 side slopes.

S = Variable width of side slope.

D = Variable width ditch - 20' maximum on 10:1 slope - Any additional width required to be on a 0:0 grade

F.L. = Flow line of culvert on ℄ (Note on cross-section). Dot culvert outline in at the proper cross-section station or nearest cross-section to it. Keep in mind that skewing the culvert will increase the length of culvert required. Place culvert low enough to drain borrow pits & increase the length to meet a 1:1 slope from the end of the max. (5) slope. Cover to finished grade. Not less than ½ the dia. of the pipe with a minimum of 1'.

Irrigation pipe to be carried across borrow pits to a min. of 10' bearing beyond edge of borrow. Channel changing irrigation ditch to obtain right angle crossing is prohibited unless specifically recommended.

Where fall of the ground permits proper drainage, pipe culverts are to be trenched into the natural ground to a depth of ⅓ the diameter of the pipe.

Minimum irrigation pipe - 18"

Minimum cross drain pipe - 24"

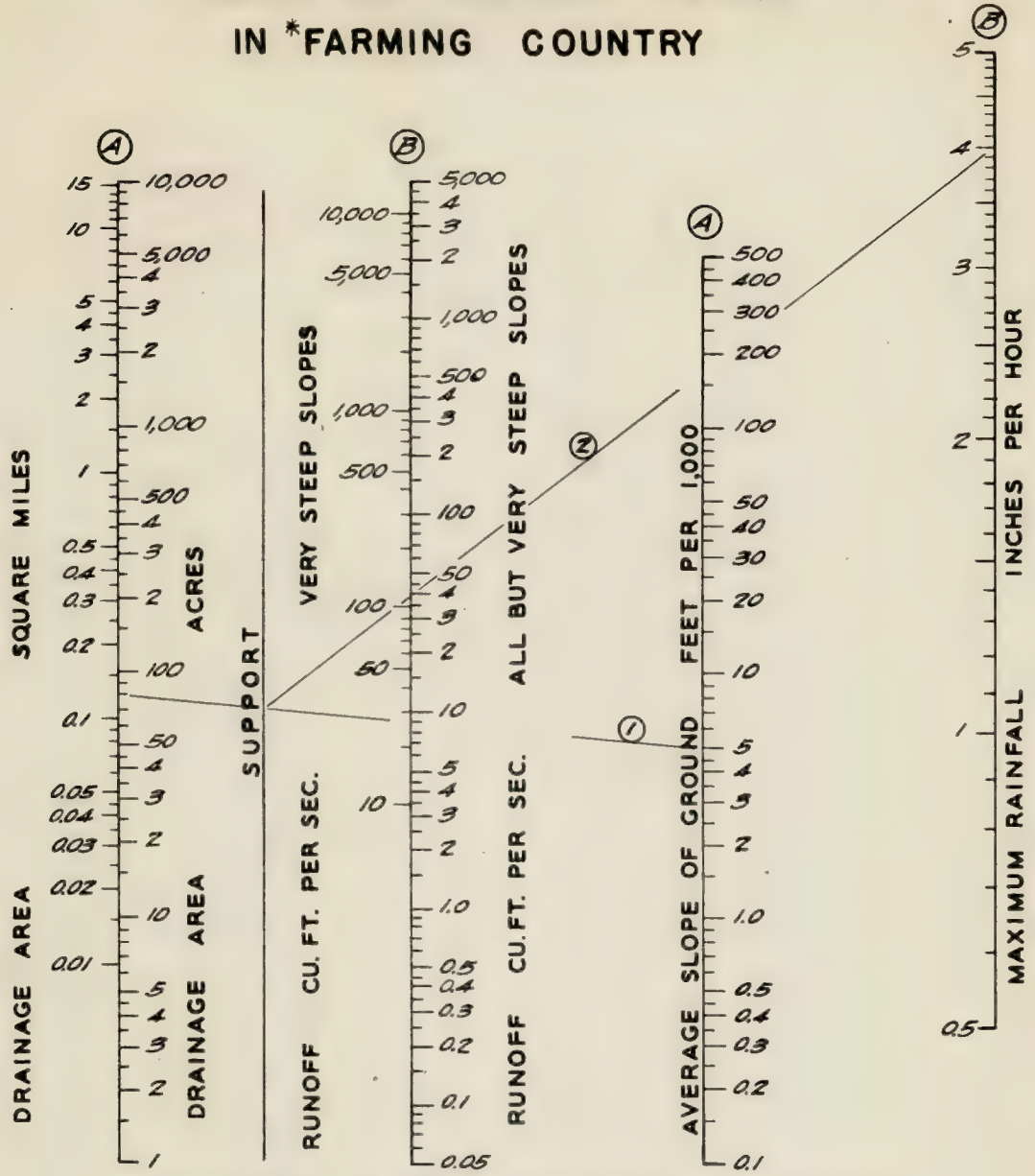
APPROVED JUN. 1, 1946

R. A. Hillcoat

ADMINISTRATIVE AID

Montana State Highway Commission

RUNOFF FOR CULVERT DESIGN IN *FARMING COUNTRY



The above chart is based on the Burkli-Ziegler formula

$$Q = MR\,c\,\sqrt{\frac{S}{M}}$$

Q = Quantity of water reaching culvert - Cubic Feet per second
R = Maximum Rainfall - Inches per hour
M = Drainage area - Acres
S = Average slope of drainage area - Feet per 1000
c = Coefficient depending on character of drainage area -
For Farming Country c = 0.25

* For Village with lawns and macadam streets - Multiply answer by 1.2
For Ordinary City Streets - Multiply answer by 2.5
For Paved Streets and Business Blocks - Multiply answer by 3.0

Example Solution

Solution lines ① and ② have been drawn for the following problem:
Given: Drainage Area = 80 Acres (0.125 sq.mi.)
Average Slope = 5 feet per 1000
Rainfall Rate = 4 inches per hour

Line ① is drawn between 80 acres on the left-hand scale Ⓐ to 5 feet per 1000 on the right-hand scale Ⓐ. Line ② is drawn from 4 inches per hour on right-hand scale Ⓑ to support line. On left-hand "Runoff" scale Ⓑ a value of 40 cubic feet per second will be noted.

For size of culvert to use refer to Capacity of Culverts Table. For 40 cubic feet per second discharge with 0.5% slope and a free outlet a 42 inch culvert would be required. For a submerged outlet refer to capacity of culvert Table Case II in the "Handbook of Culvert and Drainage Practice" by Armco Manufacturers' Association. A 54 inch culvert would be required for a submerged outlet.

For mountainous country with very steep slopes a higher coefficient is used and is taken care of by the second "Runoff" scale on the above chart.

Montana State Highway Commission.

APPROVED JUN. 1, 1946
P. A. Villecomb
ADMINISTRATIVE AID

CULVERT *GAUGE TABLE

MINIMUM GAUGE* OF CORRUGATED METAL CULVERTS FOR VARIOUS HEIGHTS OF FILL.

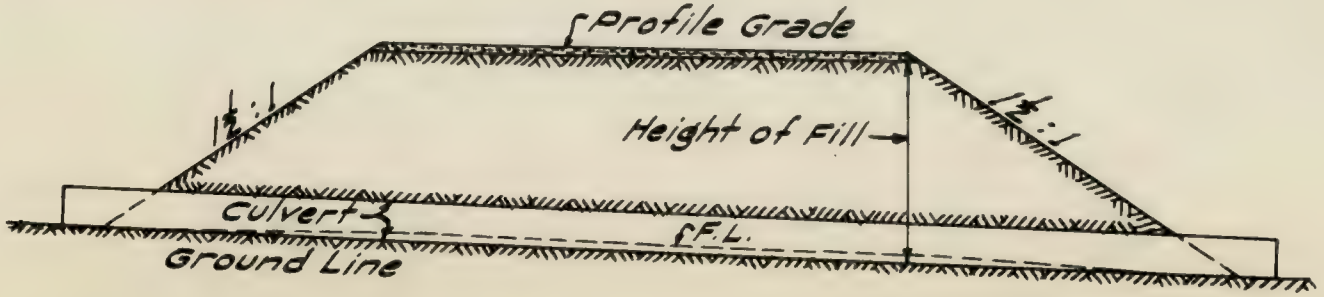
DIA. INCHES	AREA SQ. FT.	FILLS UP TO 15'	15' TO 20' FILL	20' TO 25' FILL	25' TO 30' FILL	30' TO 35' FILL	35' TO 40' FILL	40' TO 45' FILL	45' TO 50' FILL	50' TO 60' FILL	60' TO 70' FILL	70' TO 80' FILL	80' TO 100' FILL
12	.79	16	16	16	16	16	16	16	16	16	14	14	14
15	1.23	16	16	16	16	16	16	16	16	14	14	12	12
18	1.77	16	16	16	16	16	16	14	14	14	12	12	12
24	3.14	14	14	14	14	14	14	14	12	12	12	10	10
30	4.91	14	14	14	14	12	12	12	10	10	10	⊛ 8	8
36	7.07	12	12	12	12	10	10	10	8	8	8	8	8
42	9.62	12	12	12	10	10	8	8	8	8	8	8	8
48	12.57	12	12	12	10	10	8	8	8	8	8	8	8
60	19.64	10	10	10	8	8	8						
72	28.27	10	8	8									
84	38.49	8	8										

⊛ To be trenched one diameter.

Culverts below the heavy line to be strutted during installation as per Standard Specifications.

* United States Standard Gauge.

Dotted line designates minimum gage.



SKETCH SHOWING WHERE HEIGHT OF FILL IS MEASURED FOR THE ABOVE TABLE.

Montana State Highway Commission.

APPROVED JUN. 1, 1946
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211 - C6

CAPACITY OF CULVERTS WITH FREE OUTLET

IN CUBIC FT. PER SECOND

SLOPE %	DIAMETER OF PIPE. IN INCHES														
	15	18	24	30	36	42	48	54	60	72	84	90	96	108	120
0.1	1.3	2.1	4.7	8	12	20	25	36	47	85	130	160	190	270	330
0.2	2.0	3.1	6.8	12	19	30	42	57	77	130	190	230	270	380	500
0.3	2.4	3.9	8.3	15	25	37	53	72	97	150	230	280	330	450	600
0.4	2.8	4.4	9.5	17	28	42	62	83	110	180	270	320	380	510	670
0.5	3.0	4.9	10.	19	31	46	68	90	120	190	290	340	410	560	730
0.6	3.3	5.4	11.	21	33	50	72	97	130	210	300	360	430	580	770
0.8	3.7	6.1	13.	23	37	55	77	100	140	220	320	390	460	620	810
1.0	4.0	6.5	14.	24	39	57	80	110	140	230	330	400	470	630	810
1.2	4.3	6.8	14.	25	40	59	82	110	150	230	330	400	470	630	810
1.4	4.4	7.0	15.	25	40	59	83	110	150	230	330	400	470	630	810
1.6	4.5	7.1	15.	26	40	59	83	110	150	230	330	400	470	630	810
1.8	4.6	7.1	15.	26	40	59	83	110	150	230	330	400	470	630	810
2.0	4.6	7.1	15.	26	40	59	83	110	150	230	330	400	470	630	810
2.2	4.6	7.1	15.	26	40	59	83	110	150	230	330	400	470	630	810
2.4	4.6	7.1	15.	26	40	59	83	110	150	230	330	400	470	630	810

Note: The values below the heavy line indicate discharge at the approximate "critical slope" beyond which the discharge remains constant for the given size culvert.

This table is to be used, with the graph for "Runoff in Farming Country," based on the Burkli-Ziegler formula, when accurate flood data is not available.

When accurate flood data, such as restricted channel sections with high water marks, slope of stream, etc., is available, the quantity of water in cubic feet per second, reaching the culvert will be computed by Mannings formula, and the size of culvert to use determined by the above table

Manning's Formula

$$Q = A \frac{1.486}{n} R^{2/3} S^{1/2}$$

Q = Quantity of water reaching the culvert - Cubic feet per second

A = Cross-sectional area of flow - Square feet.

n = Coefficient of roughness whose value depends on the character of the surface over which the water is flowing - For open channels the value ranges from 0.25 to 0.40

R = Mean hydraulic radius - In feet = $\frac{\text{Area of section}}{\text{Wetted Perimeter}}$

S = Slope or grade - Feet per foot.

Approved JUN. 1, 1946

R. H. Willcomb

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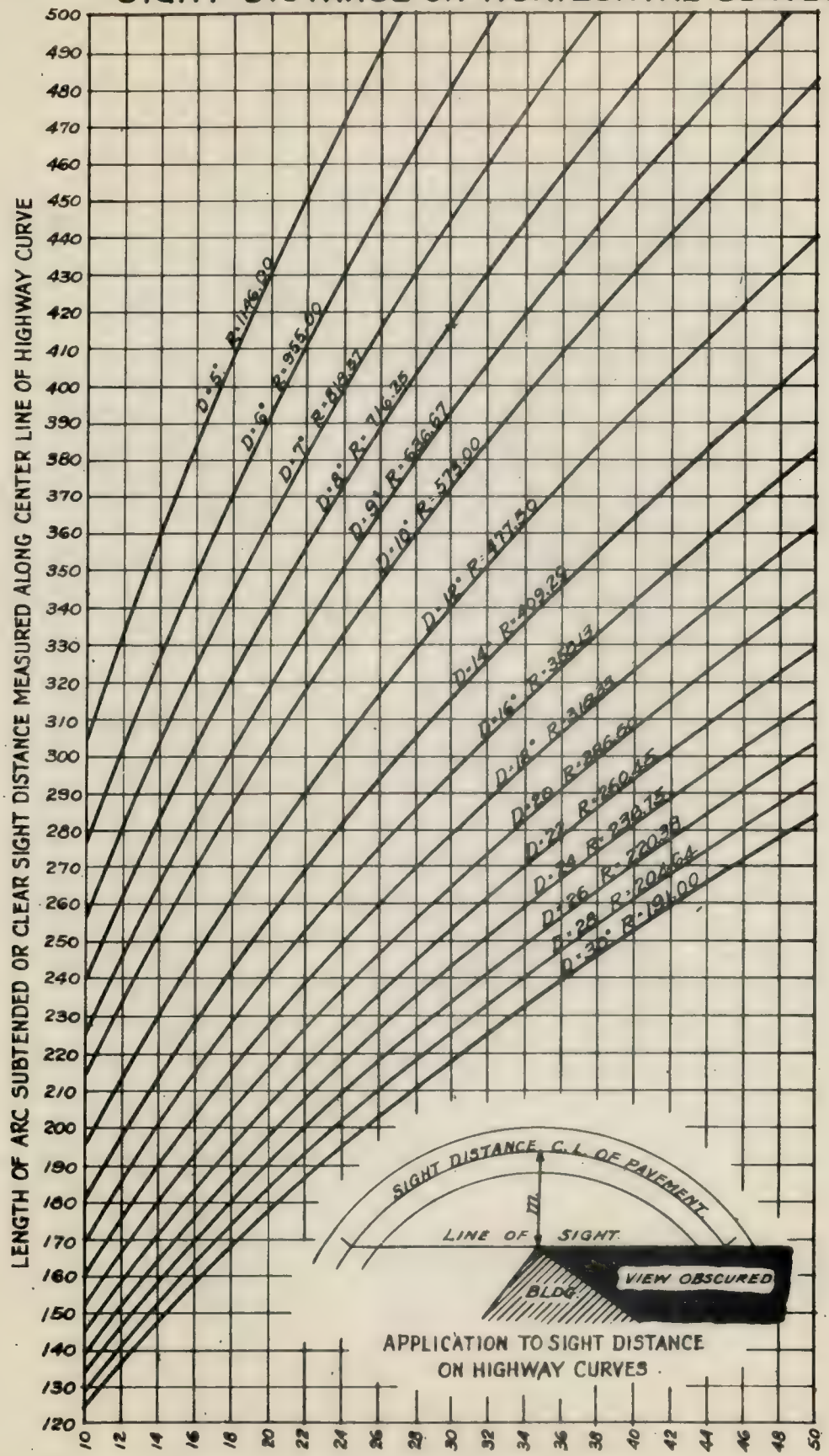
Montana State Highway Commission

SIGHT DISTANCE ON HORIZONTAL CURVES.



Montana State Highway Commission.

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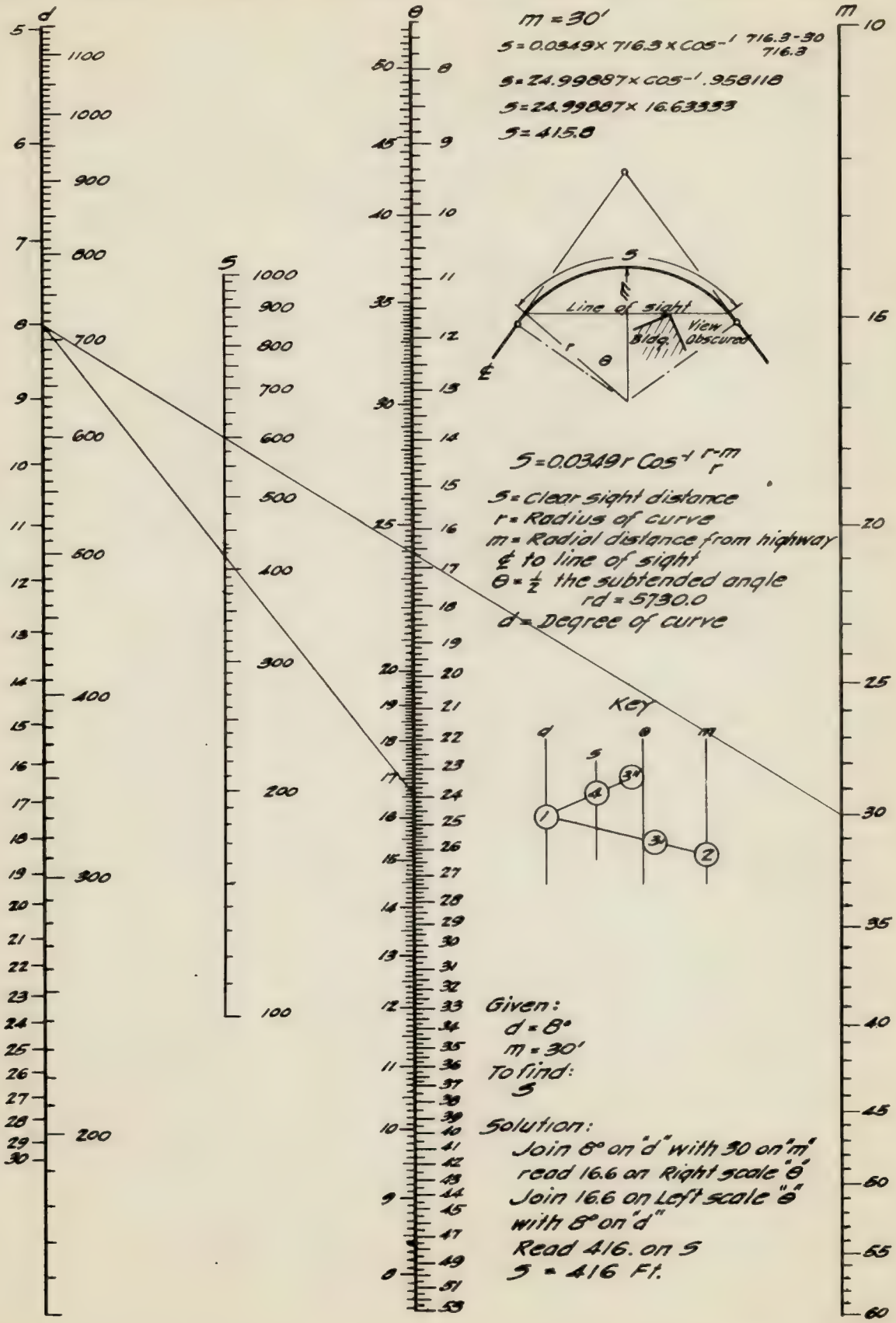
SIGHT DISTANCE ON HORIZONTAL CURVES



m = 30'

$S = 0.0349 \times 716.3 \times \cos^{-1} \frac{716.3 - 30}{716.3}$

$S = 24.99887 \times \cos^{-1} .958118$

$S = 24.99887 \times 16.63333$

$S = 415.8$

$S = 0.0349 r \cos^{-1} \frac{r-m}{r}$

S = Clear sight distance
r = Radius of curve
m = Radial distance from highway ℄ to line of sight
θ = ½ the subtended angle
rd = 5730.0
d = Degree of curve

Montana State Highway Commission

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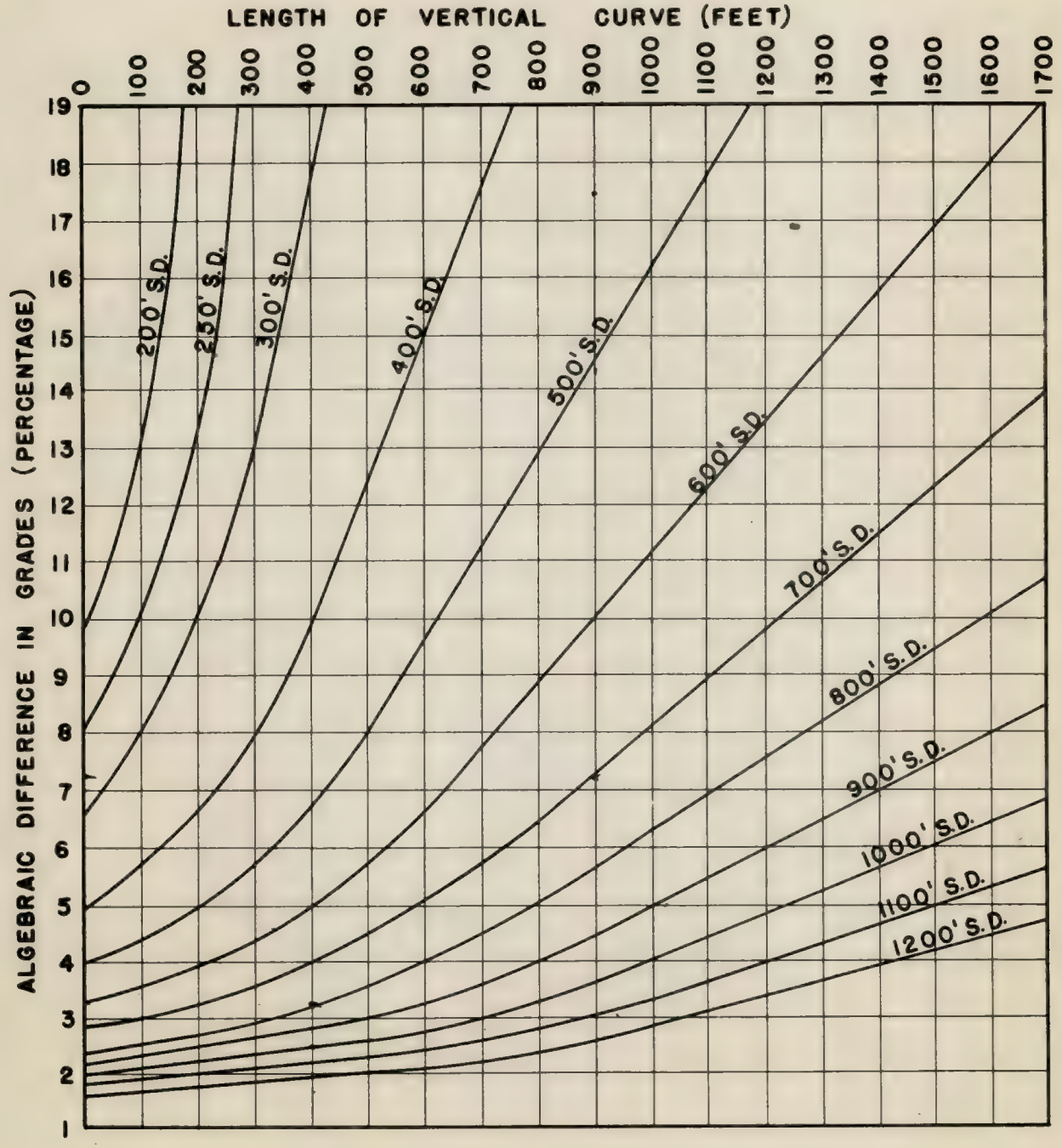
VERTICAL CURVES REQUIRED FOR VARIOUS SIGHT DISTANCES

BASED ON HEIGHT = 4 1/2 FEET



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TABLES FOR WIDENING & SUPERELEVATION

SUPERELEVATION			
DEGREE OF CURVE	WIDTH of ROADWAY		
	24'	26'	30'
1°	0.4'	0.5'	0.6'
1° 30'	0.7'	0.7'	0.8'
2°	0.9'	1.0'	1.1'
2° 30'	1.1'	1.2'	1.4'
3°	1.3'	1.5'	1.7'
3° 30'	1.6'	1.7'	2.0'
4°	1.8'	1.9'	2.2'
4° 30' AND OVER	2.0'	2.2'	2.5'

This Table is based on the Formula $E = 0.067 \frac{V^2}{R}$

E = Rate of superelevation in feet per foot of width
V = Speed of vehicles in miles per hour (40 MPH)
R = Radius of Curve in feet.

NOTES

Superelevation shall be rotated about Profile Grade elevations, less normal crown, carried on the inside of the curve one-half the width of finished roadway from centerline, and shall begin on the tangent 100 feet from the the end of the curve, increasing uniformly only the elevation of the outside shoulder until the outside half of the roadway is on a plane with the crown of the inside half; then uniformly increasing the superelevation the whole width of the roadway on a flat plane until full elevation is reached at the P.C. Carry full superelevation on a flat plane from P.C. to P.T. and from P.T. to 100 feet beyond on tangent decrease uniformly the reverse of the increase up to the P.C.
Maximum Superelevation is one inch per foot of width. When the distance from the P.T. to the next P.C. is less than 200 feet and the curves are in the same direction, Superelevation shall be uniform between them in proportion to the superelevation of each; when the curves are in opposite directions a flat section shall be used at the mid-point and superelevation proportioned to P.C. and P.T.

Where property is closely built up in municipalities, and elsewhere, and at intersections and where other special speed restrictions exist, the rate of superelevation is to be modified to conform to reasonable speed requirements.

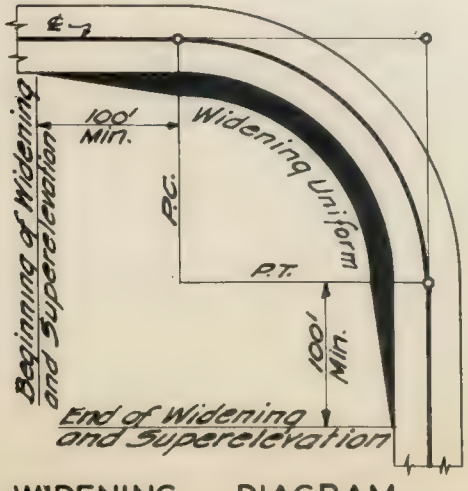
WIDENING

DEGREE	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26° & UP
WIDENING	0	1'	1'	1'	2'	2'	2'	2'	3'	3'	3'	3'	3'	3'	3'	3'	3'	4'	4'	4'	4'	4'	4'	5'

THIS TABLE IS BASED ON THE FORMULA - $W = 2\left(R - \sqrt{R^2 - L^2}\right) + \frac{V}{\sqrt{R}}$

W = TOTAL WIDENING IN FEET
R = RADIUS OF THE CURVE IN FEET
L = WHEELBASE OF VEHICLE IN FEET = (20 FEET)
V = SPEED

Where the distance from the P.T. to the next P.C. is less than 200 ft. and the curves are in the same direction, the widening shall be continuous between them. If the curves are in opposite directions widen for each as per diagram.



WIDENING DIAGRAM

Formula for Superelevation

$$\text{Elevation} = 0.067 \times \frac{\text{Velocity}^2}{\text{Radius}}$$

Formula for Widening

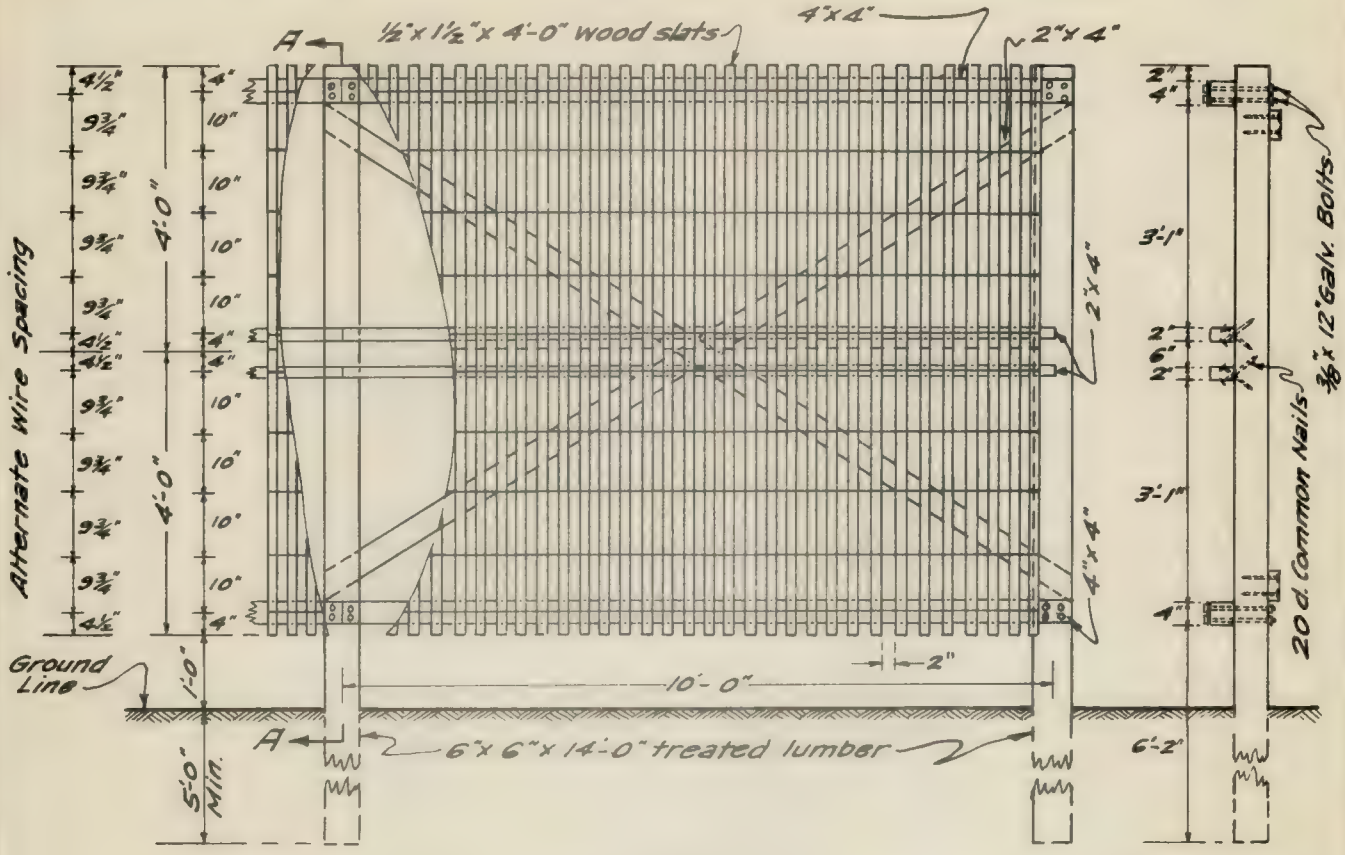
$W = 2\left(R - \sqrt{R^2 - L^2}\right) + \frac{V}{\sqrt{R}}$

R = Radius
L = Wheelbase = 20 feet
V = Velocity = 40 MPH

APPROVED JUN. 1, 1946
R. A. Willcomb
ADMINISTRATIVE AID

WOVEN WIRE WOOD SLAT SNOW FENCE (DOUBLE HEIGHT)

NOTE:- 2"x4" & 4"x4" bracing cut to fit field staking.



ELEVATION
Scale ⅜" = 1'-0"

SECTION A-A

WOOD SLATS: See Standard Specifications for Wood Slat Snow Fence.

LUMBER: All lumber shall be untreated except 6"x6"x14'-0 posts which shall be treated as called for in the Standard Specifications. All holes shall be bored before treatment. Lumber shall be Pacific Coast Douglas fir or an approved equal and shall be equal to the grade defined as select common in accordance with American Lumber Standards for soft wood lumber.

BOLTS: 4"x4" Stringers to be bolted to 6"x6" Posts with ⅜" Galvanized Bolts using 1½" Diam. Galvanized Washers between all bolt heads and nuts and the wood.

STAPLES: Wood slat snow fence to be stapled to stringers with 1" Galvanized Staples using 21 Staples per row per 10'-0" section.

BRACES: 2"x4" braces to be used at each end section, and at 100' intervals where length of fence permits.

NAILS: 2"x4" Stringers and braces to be nailed or toe-nailed to 6"x6" posts with 20d. common nails.

TAMPING: Backfill around posts shall be thoroughly tamped and compacted. Watering shall be resorted to for thorough compaction if required by the Engineer.

Approved JUN. 1, 1946
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LUMBER TABLE

218-L

SIZE	LENGTH																	
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2 x 4	4	5+	7-	8	9+	11-	12	13+	15-	16	17+	19-	20	21+	23-	24	25+	27-
2 x 6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2 x 8	8	11-	13+	16	19-	21+	24	27-	29+	32	35-	37+	40	43-	45+	48	51-	53+
2 x 10	10	13+	17-	20	23+	27-	30	33+	37-	40	43+	47-	50	53+	57-	60	63+	67
2 x 12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
3 x 4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
3 x 6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
3 x 8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	78
3 x 10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
3 x 12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
4 x 4	8	11-	13+	16	19-	21+	24	27-	29+	32	35-	37+	40	43-	45+	48	51-	53+
4 x 6	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
4 x 8	16	21+	27-	32	37+	43-	48	53+	59-	64	69+	75-	80	85+	91-	96	101+	107-
4 x 10	20	27-	33+	40	47-	53+	60	67-	73+	80	87-	93+	100	107-	113+	120	127-	133+
4 x 12	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
6 x 6	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
6 x 8	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
6 x 10	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
6 x 12	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
*8 x 8	32	43-	53+	64	75-	85+	96	107-	117+	128	139-	149+	160	171-	181+	192	203-	213+
8 x 10	40	53+	67-	80	93+	107-	120	133+	147-	160	173+	187-	200	213+	227-	240	253+	267-
8 x 12	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320
°8 x 16	64	85+	107-	128	149+	171-	192	213+	235-	256	277+	299-	320	341+	363-	384	405+	427-
10 x 10	50	67-	83+	100	117-	133+	150	167-	183+	200	217-	233+	250	268-	283+	300	317-	333+
10 x 12	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400
12 x 12	72	96	120	144	168	192	216	240	264	288	312	336	360	384	408	432	456	480
12 x 14	84	112	140	168	196	224	252	280	308	336	364	392	420	448	476	504	532	560
14 x 14	98	131-	163+	196	229-	261+	294	327-	359+	392	425-	457+	490	523-	555+	588	621-	653+
*6 x 18	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360
°8 x 18	72	96	120	144	168	192	216	240	264	288	312	336	360	384	408	432	456	480

NOTE :- + or - means + or - ½ B.F. (For instance+) exact 859.33

Montana State Highway Commission

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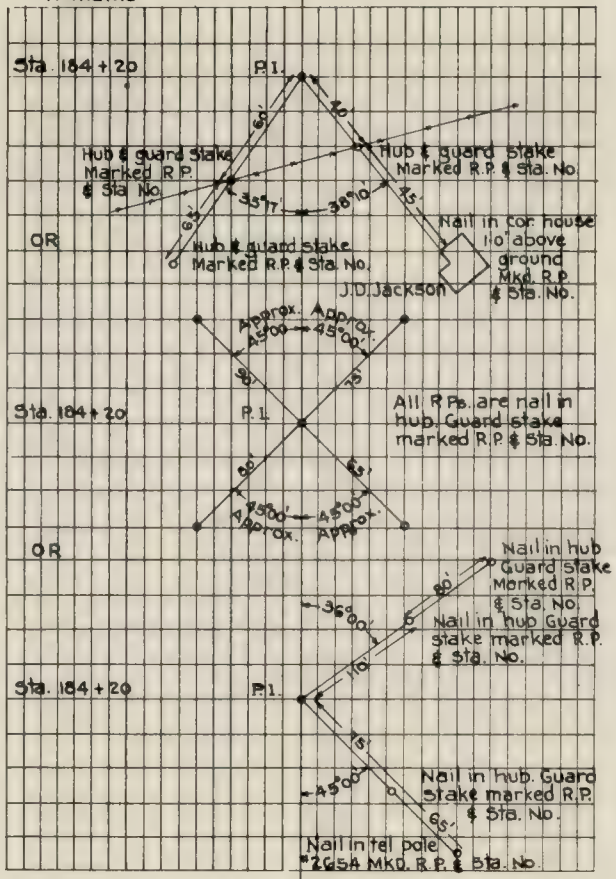
STANDARD LOCATION TRANSIT NOTES

Station	Point	Defl.	Δ	C. C.	M.C.
EQUATION				S 26°00'E.	S 06°05'E.
187+19.5 = 185+20.5	AHEAD P.T. BACK	10°05'			
185+00		9°34'			
184+00		7°04'			
					P.I. 184+20
					Δ = 20°10' Rt.
					D = 5°
					T = 203.8'
183+00		4°34'			L = 403.3'
					R = 1146.0'
182+00		2°04'			
181+17.2	P.C. 5° CV. Rt.				
				S 46°10'E.	S 26° 15'E.
					P.I. to P.I. 115.0'
176+00	P.O.T.				

Johnson - Inst.
Rogers - Chain
Williams

6-16-21
Cloudy - Warm

16



Reference Points must be firmly set and well marked so as to be easily found.

Run all curves from Harger and Bonney data.

Show detail data in proper column, how curve was staked in field.

Use sufficient space to make notes clear and distinct without crowding.

Curves may be located by deflection angles or tangent offsets.

When the deflection angle is 30° or greater the P.I. may be referenced by two R.Ps. on the back tangent produced ahead or the new tangent produced back. Measure distances to R.Ps.

Montana State Highway Commission

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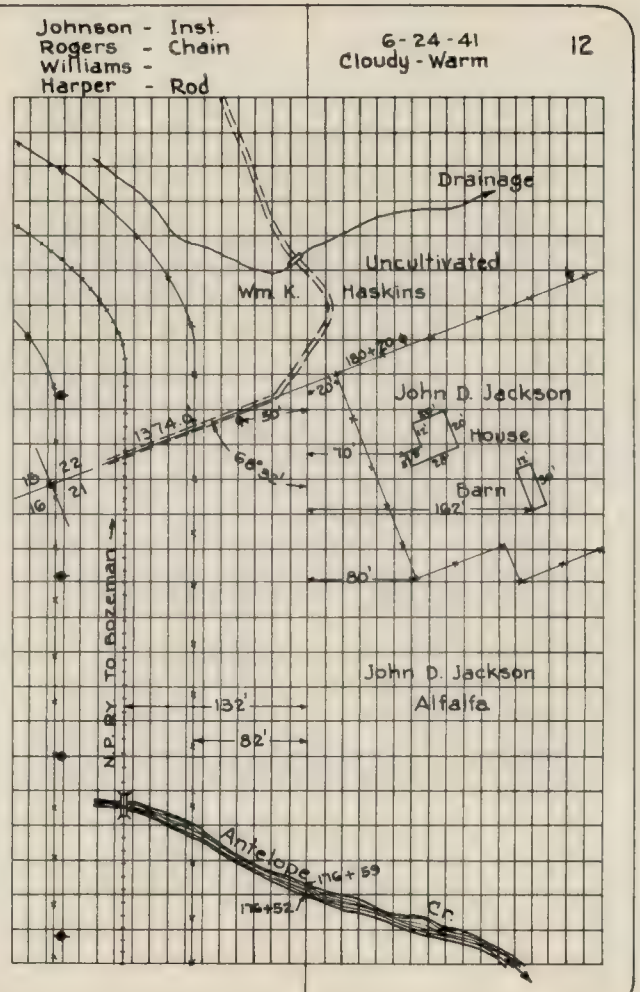
219-N1

STANDARD TOPOGRAPHY NOTES

Station	Designation	Classification
182+00		
+10	36"x 28' CM. Pipe (Poor) 2-MG Hdwlls (Poor).	
181+00	Drain in place - Remove	
	New 48"x	
+40	Old road	
+20	Section line	
180+00		
179+00		
		10% Rock
178+00		
+15	R.R. br: 15' span. plate girder	
177+00		
+59	Top of bank	
+55	Creek bed	
+52	Top of bank	
176+00		



Where ties to section lines are made on a curve, same must be taken to semi-tangent and to circular curve.

For ties to section lines see sheet No. 72, and to city limits see sheet No. 71

Show all Railroad structures and number if possible.

Designate all structures, both in place and proposed Irrigation or drainage. Show direction of flow.

For structures in place, be sure to give type and condition.

In land use, give cultivated, Beets, Pasture or Waste.

Sketch all topography using direct ℄ ties in feet. Pole lines to be identified as to kind, owner, no. of wires and clearance wherever line crosses proposed center line. (Clearance is to the lowest wire).

On Bridge survey sheets fill in all requested data.

Classification can be covered by giving the percentage of rock.

Montana State Highway Commission.

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220-N2

STANDARD CROSS SECTION AND LEVEL NOTES

Station	B.S.	H.I.	F.S.	Profile Rod Read.	Elev.	Jones - Inst. Harper - Rod / 6-20-41 Clear - Warm 17
175+80		3642.54		0.67	3641.8	Top S. rail - N.P. RY.
176+00				3.6	38.9	2.5/30 3.2/15 3.6/0 3.8/30 2.2 N.bk.Cr./140 5.8 W.S. 7.6 ℄Ch/152 4.0 H.W./159 2.1 S.bk.Cr./160
+50				3.8	38.7	1.3/50 2.5/30 3.4/18 3.8/0 10.5/3 12.7/10 10.9/17 4.2/20 4.5/50
+52				11.6	30.9	2.1/50 2.5/30 2.7/3 11.6/0 12.8/3 10.4/17 2.9/19 3.2/30
Creek Fall +57				11.6	30.9	9.6/300 10.9/200 11.2/100 11.4/50 11.4/25 11.5/15 11.6/0 11.7/30 11.8/50 11.9/100 12.3/200 12.2/300
+59				11.5	31.0	2.8/50 3.2/30 5.5/18 11.5/15 12.5/7 11.5/0 9.8/3 8.6/6 4.0/50
+60				2.9	39.6	2.2/50 2.5/30 8.7/26 11.7/20 9.5/5 2.9/0 3.3/30 4.0/60
177+00				0.4	42.1	2.2 N.bk.Cr./100 4.0 H.W./97 5.6 ℄Ch./95 4.5 W.S. 2.1 S.bk.Cr./90 0.2/10 0.4/0 0.6/15 1.5/30 1.8/50
T.P.	10.46	3652.80	0.2		42.34	
178+00				6.6	46.2	4.1/30 3.6/5 6.6/0 2.0/20 2.3/30
179+00				6.4	46.4	5.5/20 6.4/4 6.4/0 2.0/20 2.3/30
180+00				2.5	50.3	1.4/30 2.5/0 3.4/25 1.0/30
B.M. #7				0.76	3652.04	S.E. Cor. R.R. bridge abut. Top marked ⊕ 80' Lt. Sta. 180+40
+50				0.32	3652.4	Top S. rail N.P. RY.

Take levels in creek beds sufficiently far from both sides of ℄ to locate any proposed channel changes.

Take "base of rail" elevations every 1000 ft. where ℄ parallels a railway. Extend X-sections to cover same.

Note all equations in column marked "Station" as shown in transit notes.

Give description of all B.M's. and location.

Take wide sections when required for high fills, deep cuts, channel changes, interception ditches, wide borrow pits, etc.

Note all flow line elevations - both stream and irrigation ditches.

Cross section elevations when computed will be written immediately above rod reading as 39.5 / 3.2 / 15

Montana State Highway Commission.

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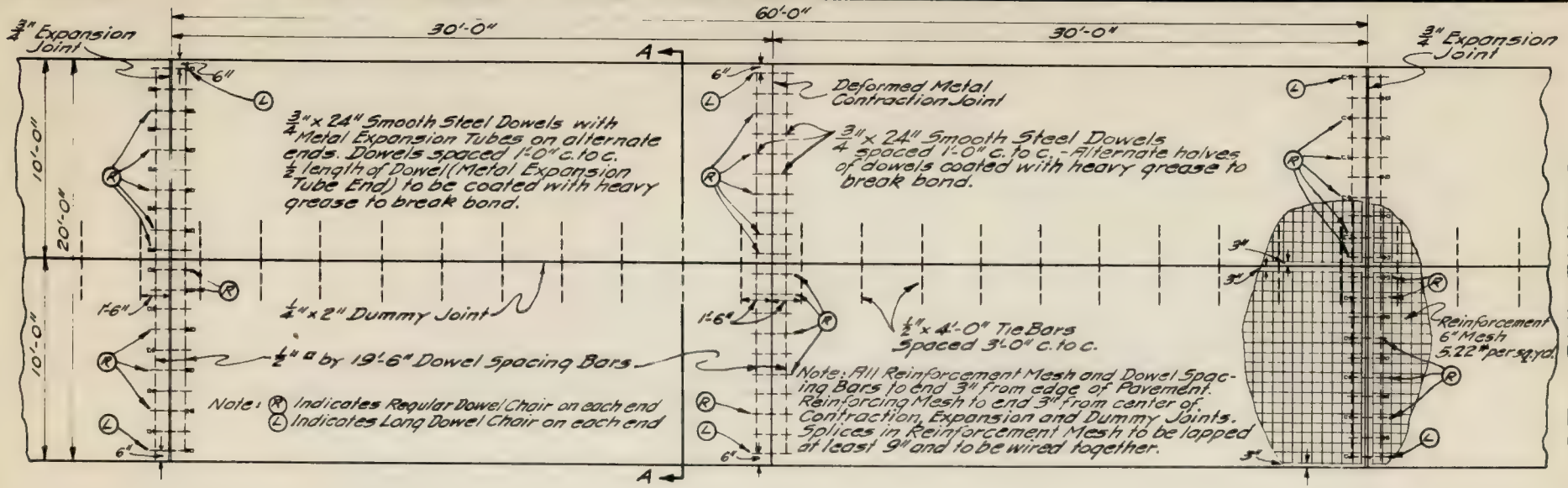
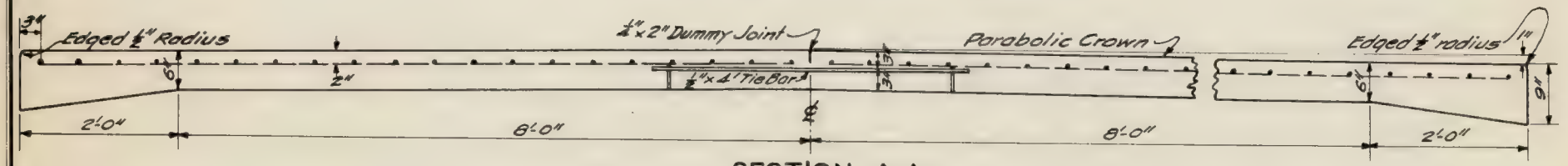
221-N3

STANDARD 20' CONCRETE PAVEMENT



PLAN OF 20' CONC. PAVEMENT



SECTION A-A

*20' of 3/4" Premolded Bituminous Expansion Joint Filler
60' of 1/4" x 2" Premolded Bituminous Filler Strip
16 cubic inches Fiberoted Bitumin Filler

CONCRETE

Area Square Feet	10.500
Cubic Yards per Station	38.889
Cubic Yards per Mile	2053.33

SURFACE AREA

Square Yards per Station	222.222
Square Yards per Mile	11733.33

6" MESH REINFORCEMENT

5.22* per Sq. Yd. 58* per 100 Sq. Ft.
Per 60' Panel = 1121.0 Sq. Ft. = 650.18 Lbs.

ITEM	No. Req. For 60' Panel
5 1/4" x 20' Deformed Metal Plate Contraction Joint (Not less than 16 gauge)	1
3/8" x 16" Pins (for Deformed Metal Plate)	7
3/4" x 24" Smooth Steel Dowels	40
8" Metal Dowel Expansion Tubes	20
Regular Dowel Chairs	40
Long Dowel Chairs	8
1/2" □ x 19'-6" Dowel Spacing Bars	4
1/2" x 4'-0" Tie Bars	20
Tie Bar Chairs	40

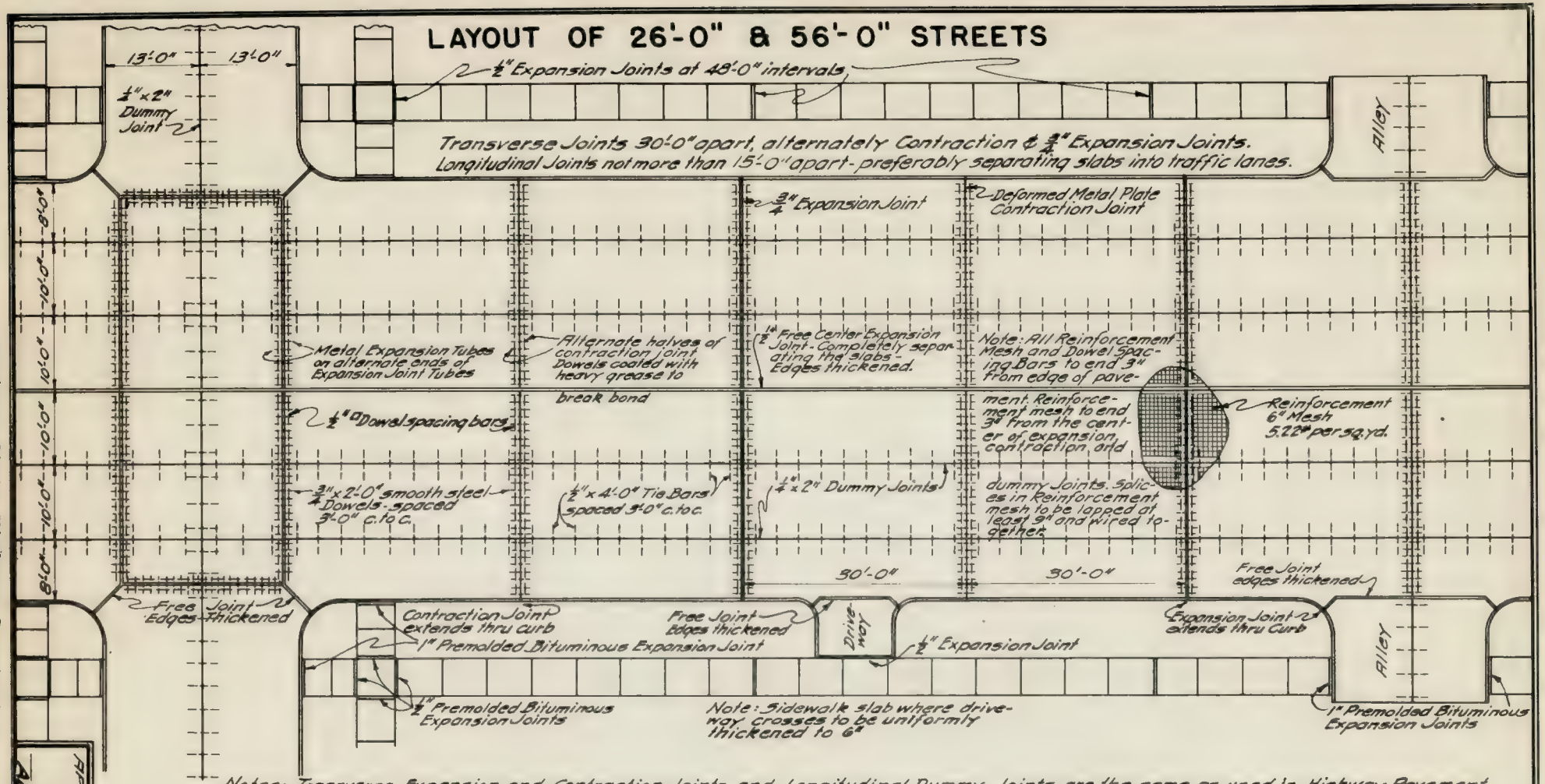
*Note: Cut to fit crown and base of Pavement Cross-section.

APPROVED JUN. 1, 1946
T. C. Atkinson
ADMINISTRATIVE AID

Montana State Highway Commission

222-P1

LAYOUT OF 26'-0" & 56'-0" STREETS



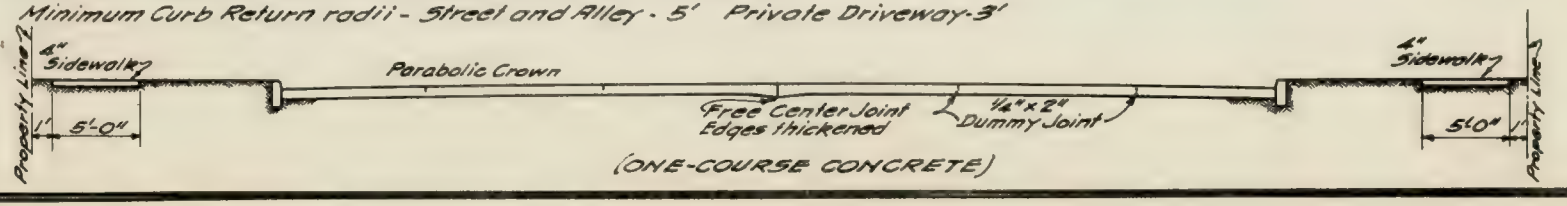
Notes: Transverse Expansion and Contraction Joints and Longitudinal Dummy Joints are the same as used in Highway Pavement. (See "Joints for Concrete Highway and Street Pavement.")

For details of Free Joints see "Special Street Joints."

1" Premolded Bituminous Expansion Joints to be placed between Sidewalk Ends and Curb, and ½" at Driveway Ends and Sidewalk; intersections of Sidewalk slabs, and around all street structures the full depth of the Pavement or Sidewalk.

Where old separate Curb in place is used, a ¼" Premolded Bituminous Expansion Joint shall be provided between the Pavement Slab and the Curb. In New Curb the Expansion and Contraction Joints of the Pavement Slab shall extend through the Curb for all three types, (Integral, Separate or Combined Curb and Gutter.)

Minimum Curb Return radii - Street and Alley - 5' Private Driveway - 3'



(ONE-COURSE CONCRETE)

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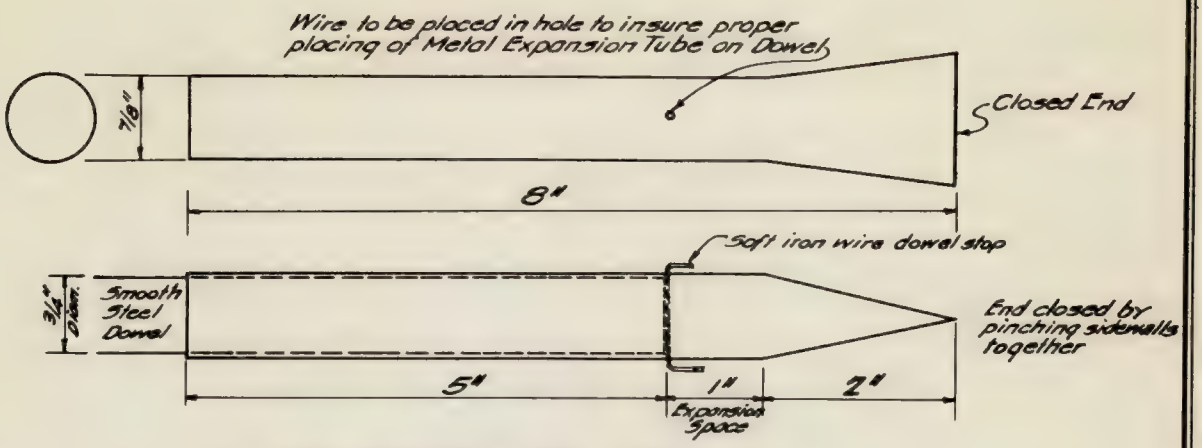
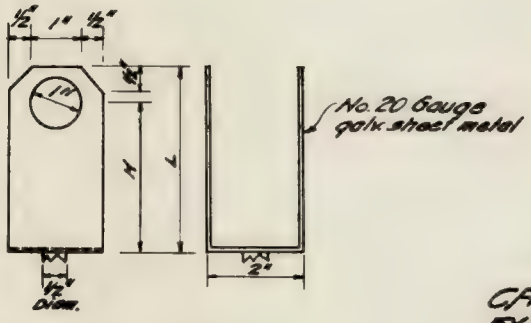
223-P2

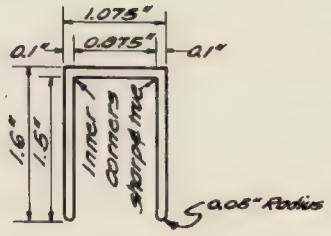
CONCRETE PAVEMENT DETAILS



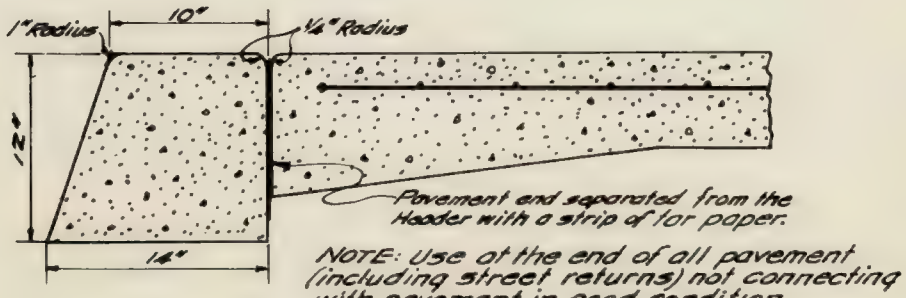
METAL EXPANSION TUBE
No. 30 Gauge Metal



DOWEL CHAIR
Regular - H = 5 1/2" L = 3 3/8"
Long - H = 5 1/2" L = 6 1/2"



CAP FOR PREMOLDED EXPANSION JOINT FILLER
A.S.T.M.-DESIGN A-107-30



NOTE: Use at the end of all pavement (including street returns) not connecting with pavement in good condition.

CONCRETE HEADER

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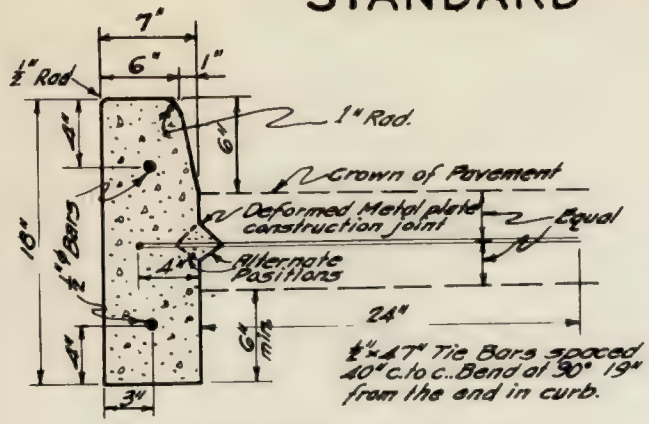
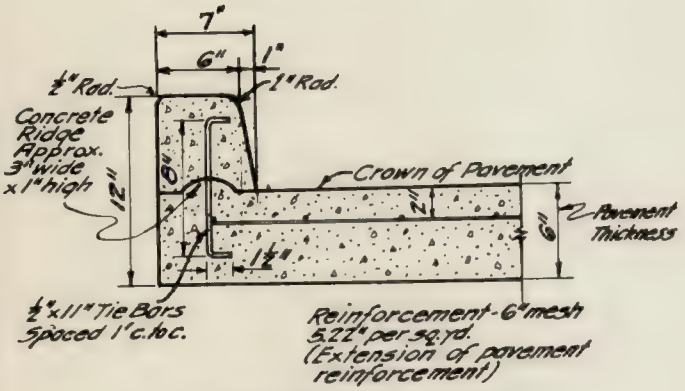
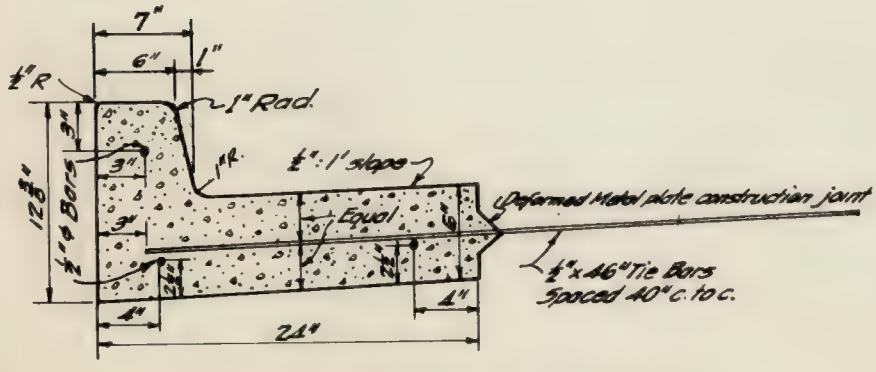
STANDARD CURB



SEPARATE CURB
(Can be built with or without tie bars)



INTEGRAL CURB



COMBINED CURB & GUTTER
(With or without tie bars)

NOTES:
Joints in curb: Separate curb (when definitely tied to pavement slab), Integral curb and Combined Curb & Gutter (when definitely tied to Pavement Slab) shall have the expansion Joint of the pavement slab extended through and shall have a ½" Premolded Bituminous Expansion Joint at every contraction joint.
Separate Curb (when not definitely tied to pavement slab) shall be divided into separate blocks 10' long by No. 10 gauge plates cut to the exact cross section of the curb, and shall have ½" Premolded Bituminous Expansion Joints at 25' intervals and at the end of all curb returns. A ½" Premolded Bituminous Expansion Joint shall be placed between the curb and the pavement slab. Combined Curb & Gutter (when not definitely tied to the pavement slab) shall be divided into blocks 10' long by V-shaped grooves ½" in depth and shall have ½" Premolded Bituminous Expansion Joints at 50' intervals and at the ends of all curb returns. A ½" Premolded Bituminous Expansion Joint shall be placed between the Curb & Gutter and the pavement slab.
Where curb cuts sidewalk or any solid structure a ½" Premolded Bituminous Expansion Joint shall be used.

Minimum Curb Return Radii - Streets & Alleys - 5'
Private Driveway - 3'
15' Radii desirable for Streets & Alleys

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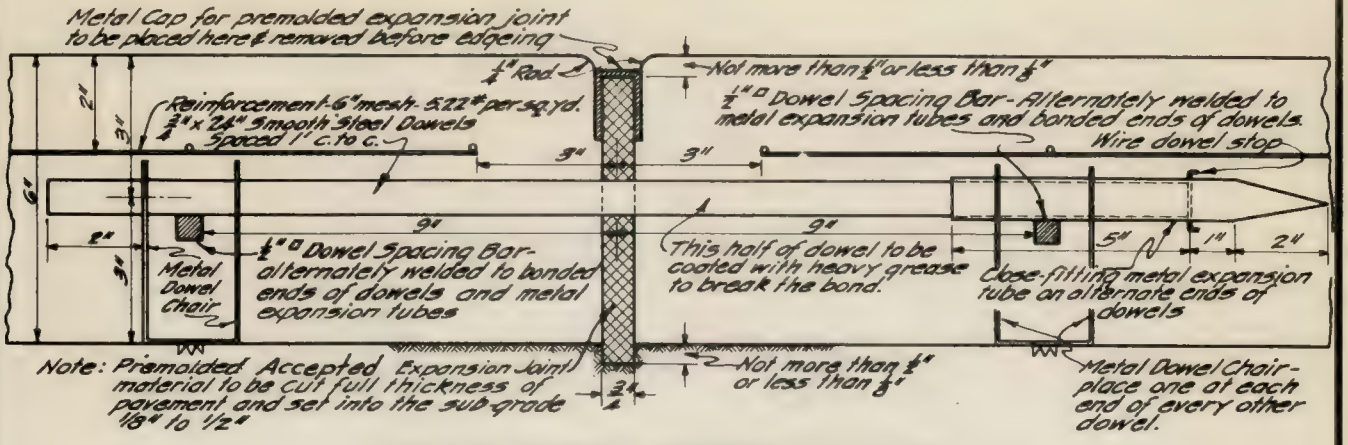
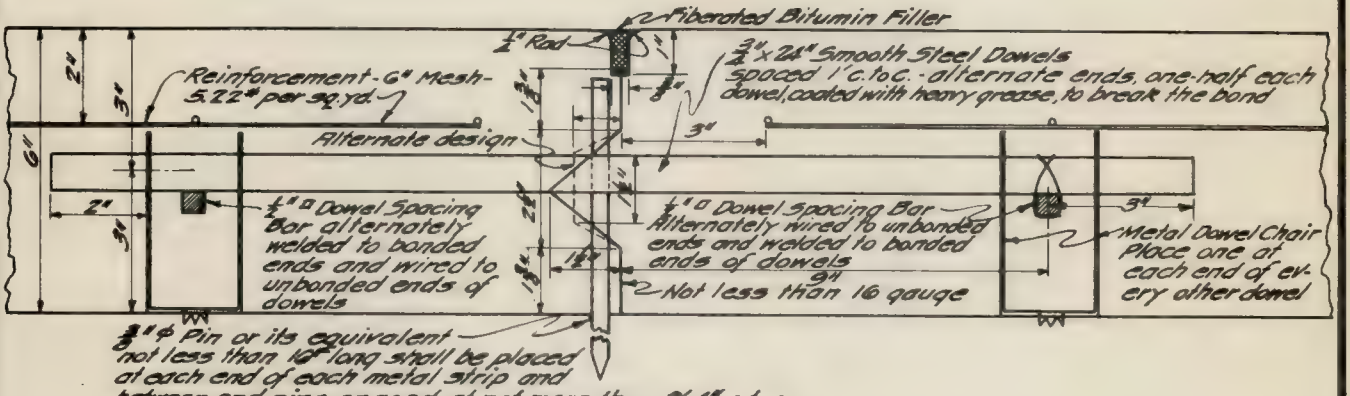
JOINTS FOR CONCRETE HIGHWAY PAVEMENT

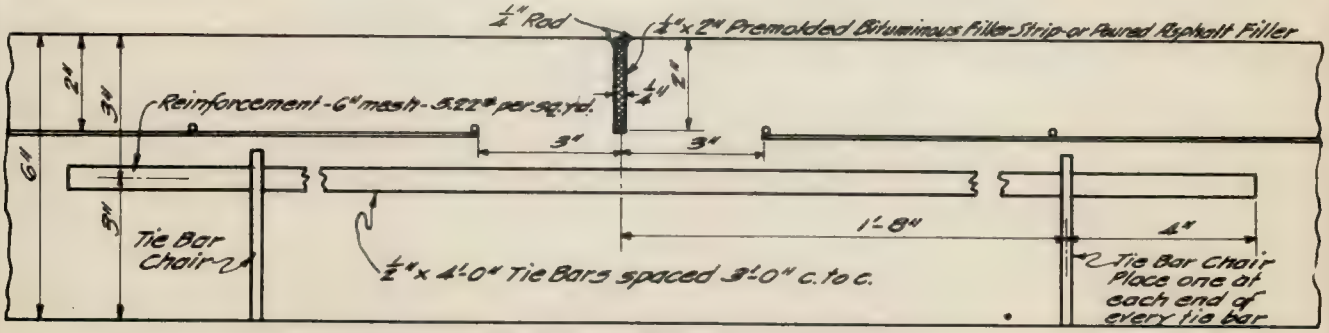


TRANSVERSE EXPANSION JOINT



TRANSVERSE CONTRACTION JOINT

Note: When this joint is used for a construction or a longitudinal joint, substitute tie bars and chairs (as shown in Dummy Joint below) for dowels and dowel chairs.



LONGITUDINAL DUMMY JOINT

Note: Expansion Joints to be spaced 60' apart with contraction joints midway between expansion joints. Premolded Expansion Joint Filler shall be cut to fit the crown and base of the pavement section and to be held in a plane vertical to the sub-grade by suitable means until the concrete has had sufficient time to assume definite form. Metal contraction joint plates shall conform to the shape of the pavement section. They shall be firmly fastened to the sub-grade by iron pins as shown and held in alignment by an approved joint spacer. Dowel holes in premolded expansion joint filler to accurately fit dowels of joint assembly.

Any device which provides for equivalent load transfer across the joints may be substituted for expansion and contraction joint dowels if approved by the Engineer.

Air cell expansion joints may be used if approved by the Engineer. They shall be adequately sealed to prevent infiltration of inert material or surface water. Air cell joints with an expansion space of 1" may be spaced 90' apart with two contraction joints equally spaced between expansion joints

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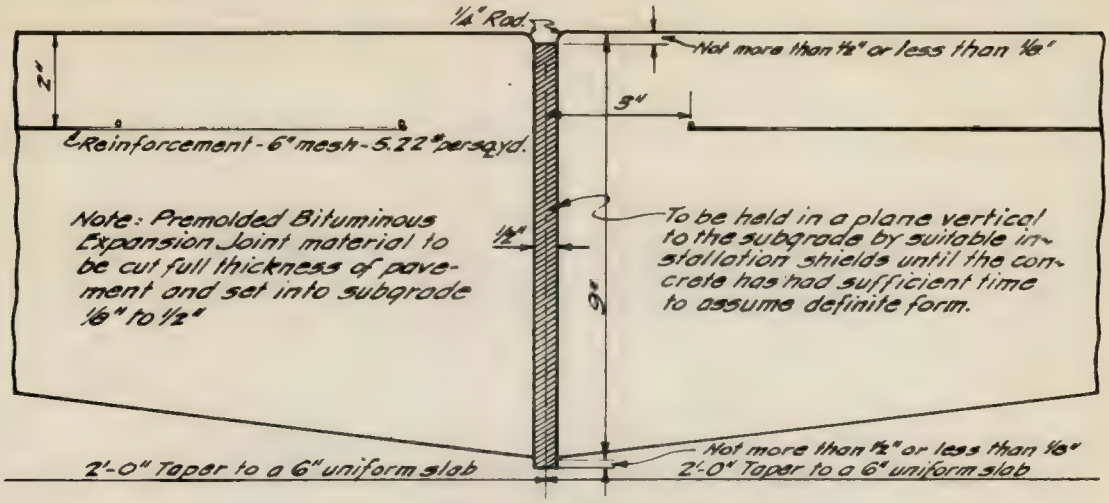
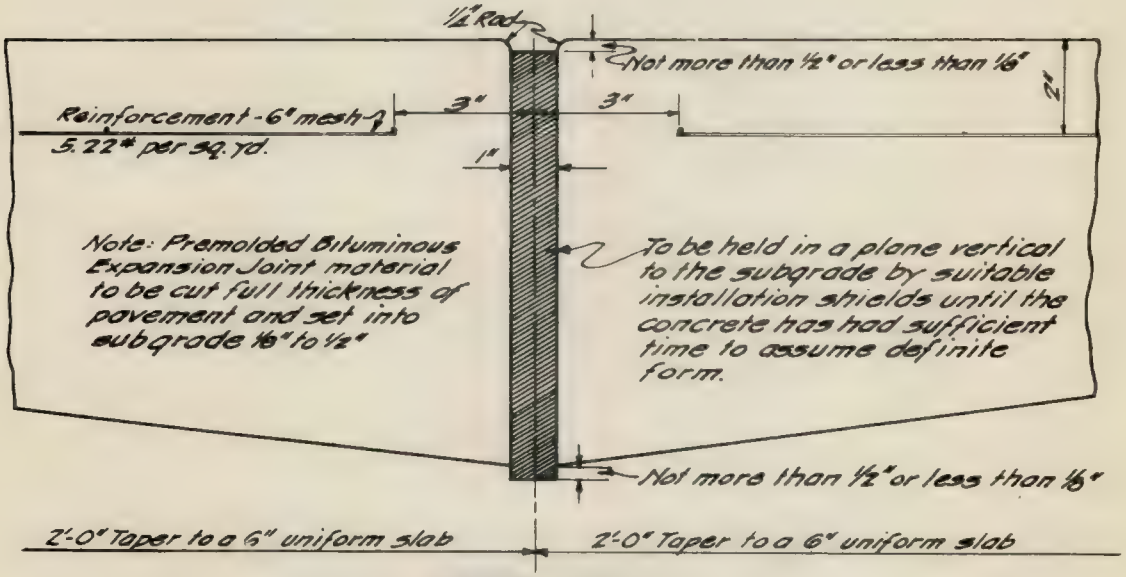
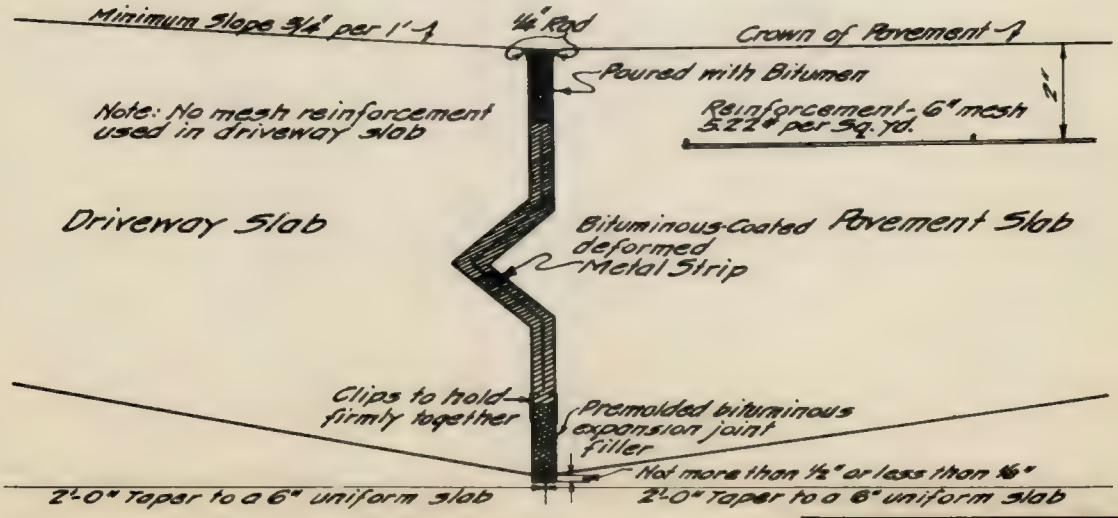
SPECIAL JOINTS FOR CONCRETE PAVEMENT



FREE CENTER JOINT



FREE JOINT
(At street intersection returns)



FREE JOINT
Driveway & Alley Returns

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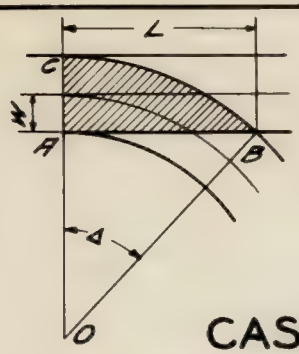
SOLUTIONS OF PAVEMENT Y AREAS



CASE 1

$AO = R - W$. $BO = R + W$

$L = AB = \sqrt{(R+W)^2 - (R-W)^2}$

$\cos \Delta = \frac{R-W}{R+W}$

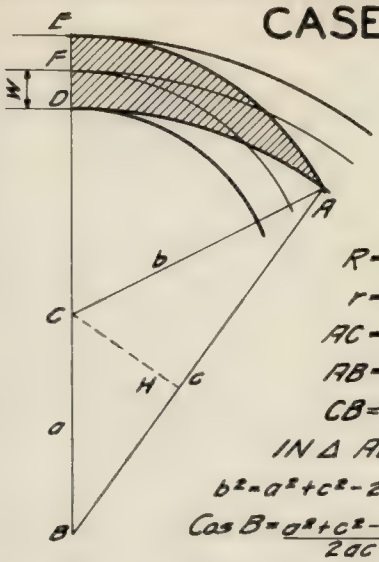
AREA OF SECTOR OBCO =

$\frac{\Delta (R+W)^2 \pi}{360}$ = AREA IN SQ. FT.

AREA OF TRIANGLE OAB =

$\frac{(R-W)L}{2}$ = AREA IN SQ. FT.

Shaded Area = Area sector OBCO − Area triangle OAB



CASE 3

R = long Radius = BF

r = short Radius = CF

AC = b = r + W

AB = c = R − W

CB = a = R − r

IN Δ ABC:

$b^2 = a^2 + c^2 - 2ac \cos B$

$\cos B = \frac{a^2 + c^2 - b^2}{2ac}$

also $\sin A : \sin B :: a : b$

$\sin A = \frac{\sin B \times a}{b}$

Angle DCA = A + B

Area Δ ABC = $\frac{ac \sin B}{2}$

$\frac{B(R-W)^2 \pi}{360}$ = Area sector ABD

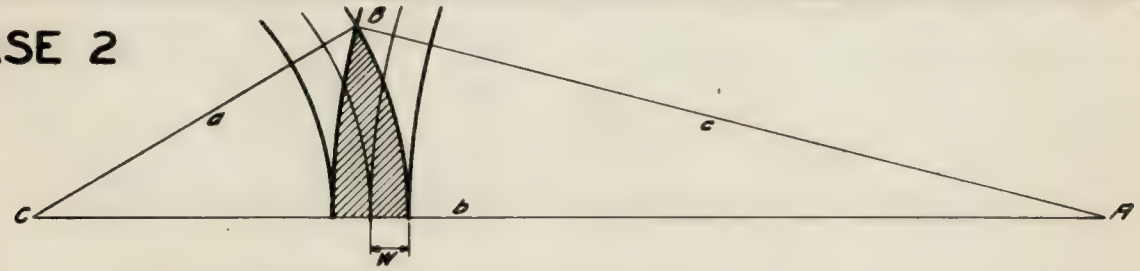
$\frac{(A+B)(r+W)^2 \pi}{360}$ = Area sector ECA

SHADED AREA

=

Δ ABC + sector EAC − sector ABD

CASE 2



R = long radius r = short radius

in Δ ABC: AB = c = R + W

BC = a = r + W AC = b = R + r

$c^2 = a^2 + b^2 - 2ab \cos C$ or $\cos C = \frac{a^2 + b^2 - c^2}{2ab}$

also $\sin A : \sin C :: a : c$ or $\sin A = \frac{\sin C \times a}{c}$

Area Δ ABC = $\frac{ab \sin C}{2}$

Area large sector = $\frac{A(R+W)^2 \pi}{360}$; Area small sector = $\frac{C(r+W)^2 \pi}{360}$

SHADED AREA =

AREA both sectors − AREA Δ ABC

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SOLUTIONS OF PAVEMENT Y AREAS

CASE 4

GIVEN RADII OF CURVES AND DISTANCE BE = y

R = FK, r = AJ, AB = r − W

FD = EF = BG = R − W, AD = r + W

IN Δ AFG: AG = R − r; FG = y

$AF = \sqrt{AG^2 + y^2}$; $\text{tang} \measuredangle A = \frac{y}{AG}$

$\text{tang} \measuredangle F = \frac{AG}{y}$

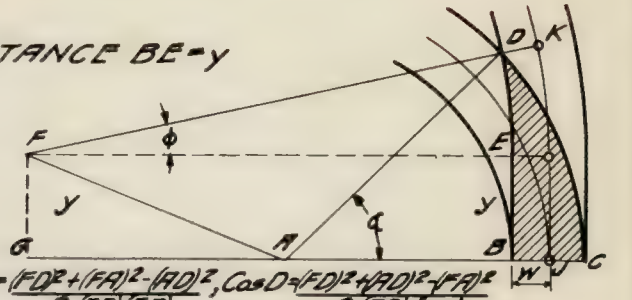
IN Δ DAF all sides solved above; $\text{Cos} F = \frac{(FD)^2 + (FA)^2 - (AD)^2}{2(FD)(FA)}$, $\text{Cos} D = \frac{(FD)^2 + (AD)^2 - (FA)^2}{2(FD)(AD)}$

$\measuredangle A = 180° - (F + D)$

$\text{AREA } \Delta DAF = \frac{(AF)\sin F (FD)}{2}$

$\text{AREA sector } DEF = \frac{\phi (R-W)^2 \pi}{360}$

$\text{AREA } \Delta AFG = \frac{y}{2}\frac{R-r}{}$

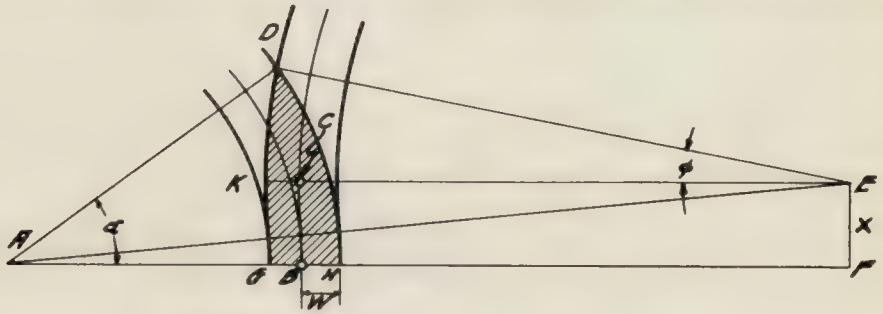


α = 180° − sum of angles at A solved previously

ϕ = Sum of angles at F solved previously − 90°

$\text{AREA sector } ADC = \frac{\alpha (r+W)^2 \pi}{360}$; AREA BEFG = (R − W) · y

SHADED AREA = (Sector ADC + Δ DAF + Δ AFG) − (Rectangle BEFG + Sector DEF)



CASE 5

AB = r CE = R BC = x all known

In Δ AEF: AF = R + r; FE = x

$AE = x^2 + (R+r)^2$; $\text{tang} \measuredangle EAF = \frac{x}{(R+r)}$

$\text{AREA } \Delta AEF = \frac{x(R+r)}{2}$;

Further: AD = r + W and ED = R + W

$\cos EAD = \frac{(AE)^2 + (AD)^2 - (ED)^2}{2(AE)(AD)}$

$\cos AED = \frac{(AE)^2 + (ED)^2 - (AD)^2}{2(AE)(ED)}$

$\measuredangle FAD = \phi = \measuredangle FAE + \measuredangle EAD$; $\measuredangle KED = \measuredangle AED - \measuredangle EAF = \alpha$

$\text{AREA } \Delta AED = \frac{1}{2}(AE)(ED)\sin AED$ $\text{AREA sector } ADH = \frac{\phi (r+W)^2 \pi}{360}$

$\text{AREA sector } EKD = \frac{\alpha (R+W)^2 \pi}{360}$ AREA FGKE = x(R + W)

SHADED AREA = (Rectangle FGKE + Sector EKD + Sector AHD) − (Δ AEF + Δ AED)

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R. A. Hillcoat
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Montana State Highway Commission

QUANTITIES FOR ESTIMATING

CLASS	POUNDS GRAVEL PER SQ. YD.		GALS OIL PER TON	GALS OIL PER SQ. YD.		
	COARSE	CHIPS	MIX	PRIME	MIX	SEAL
BITUMINOUS SURF. TREATMENT, TYPE-"A"	45-50	24		0.333		0.333
BITUMINOUS SURF. TREATMENT, TYPE-"B"		24		0.333		0.333
ROAD MIX SURFACE COURSE		24		0.25	1.4	0.333
PLANT MIX SURFACE COURSE		24	14.151	0.25		0.333

For reinforcement, increase 6" Base course gravel quantities 10 %; 9", 5 %.
For compaction, increase both Top and Base course quantities 20 %.
For estimating purposes, a cubic yard of gravel weighs 2850 pounds.
Use 20 gals. of water per ton of base and one half of top course material.
Use 15 gals. of water per cubic yard of embankment and selected borrow base.
Use one half hour per foot of width of the course for each mile of the length of cushion, selected borrow base, and top for estimating Rolling of each Tift.
To provide for contingencies, add 20 % to Overhaul quantities.
All metal pipe culv. are made in 2 ft. multiples.
All conc. pipe culv. are made in 4 ft. or 6 ft. multiples.

Montana State Highway Commission.

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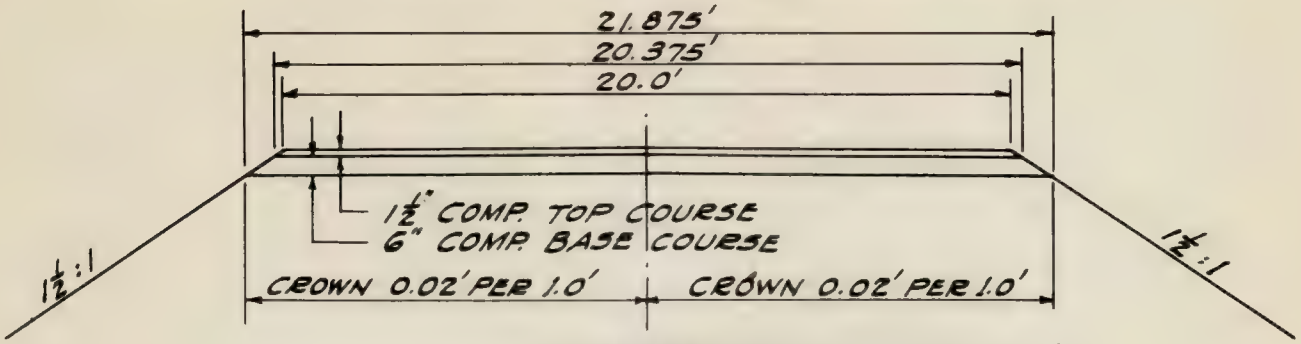
SURFACING FOR BRIDGES & APPROACHES

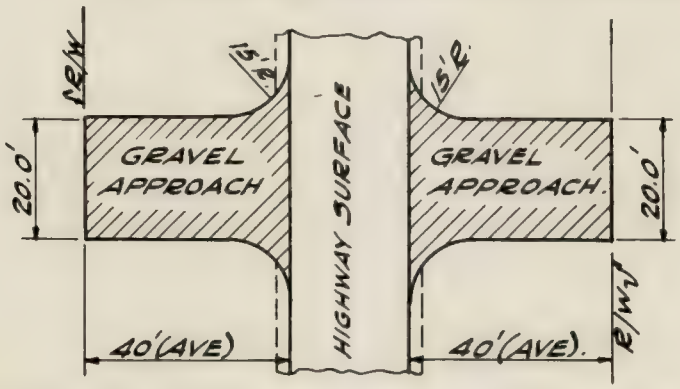
GRAVEL SURFACE APPROACH.



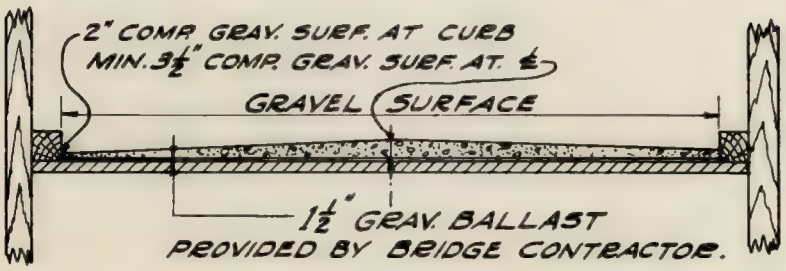
QUANTITIES (ONE SIDE ONLY)

TONS 1½" COMP. TOP COURSE - 6
TONS 6" COMP. BASE COURSE - 25

GRAVEL = 2850# PER CU. YD.
ADD 20 % FOR COMPACTION ON SUMMARY SHEET.



GRAVEL SURFACE BRIDGE



GRAVEL SURFACE	
BR. RDWAY WIDTH	TONS PER LIN. FT. TOP COURSE
24'	0.291
26'	0.315
28'	0.338
30'	0.362
32'	0.386

ADD 20 % FOR COMPACTION ON SUMMARY SHEET.

Montana State Highway Commission.

APPROVED - JUN. 1, 1946.
D.M. Willcoxon
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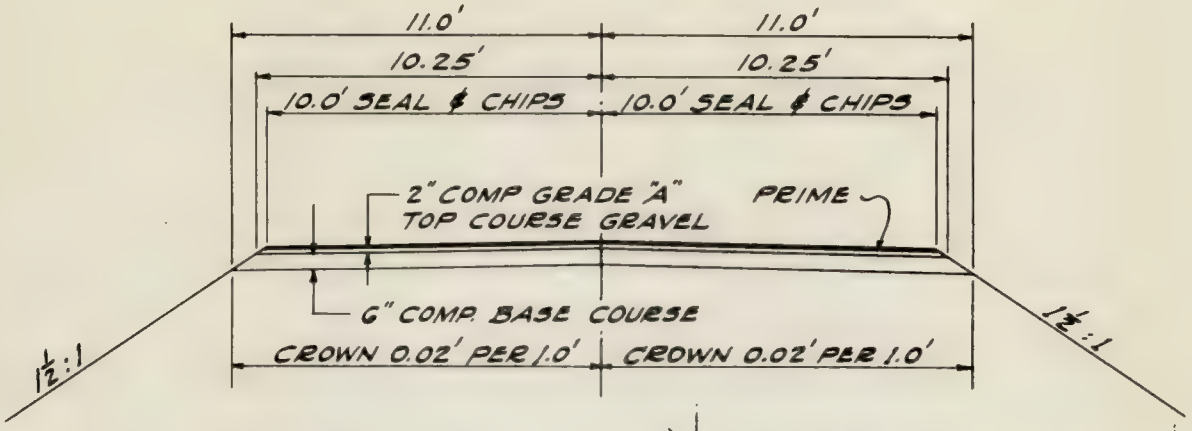
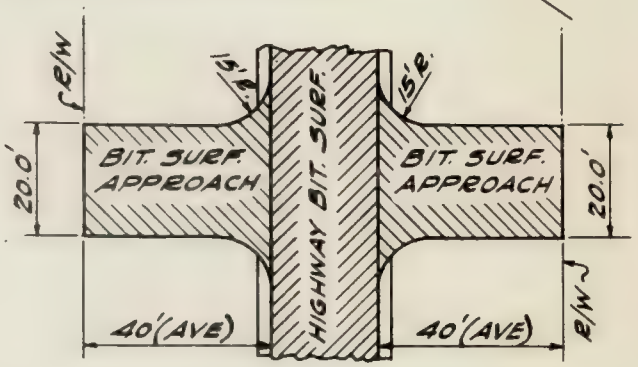
SURFACING FOR BRIDGES & APPROACHES

DOUBLE PRIME BITUMINOUS SURFACE APPROACH



QUANTITIES
(ONE SIDE ONLY).

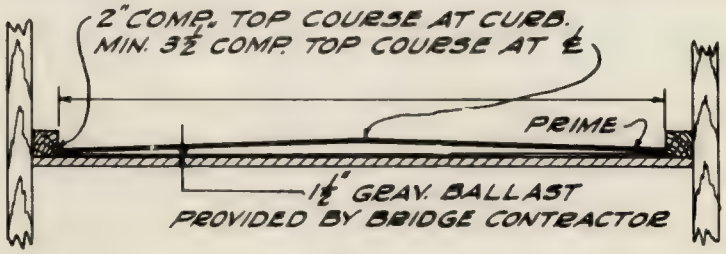
TONS 6" COMP. BASE COURSE	25
TONS 2" COMP. TOP COURSE	8
TONS STONE CHIPS	2
GALS PRIME OIL	34
GALS SEAL OIL	34



CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
PRIME OIL = 0.333 GAL. PER SQ. YD.
SEAL OIL = 0.333 GAL PER SQ. YD.

ADD. 20% FOR COMPACTION ON SUMMARY.

DOUBLE PRIME BITUMINOUS SURFACE BRIDGE DECK.



DOUBLE PRIME BIT. SURFACE				
BR. RDWAY WIDTH	TONS PER LIN. FT. CHIPS	TONS PER LIN. FT. TOP COURSE	GAL. PER LIN. FT. PRIME	GAL. PER LIN. FT. SEAL
24'	0.032	0.291	0.889	0.889
26'	0.035	0.315	0.962	0.962
28'	0.037	0.338	1.036	1.036
30'	0.040	0.362	1.110	1.110
32'	0.043	0.386	1.184	1.184

CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
PRIME OIL = 0.333 GAL PER SQ. YD.
SEAL OIL = 0.333 GAL PER SQ. YD.
ADD 20% FOR COMPACTION ON SUMMARY SHEET.

Montana State Highway Commission

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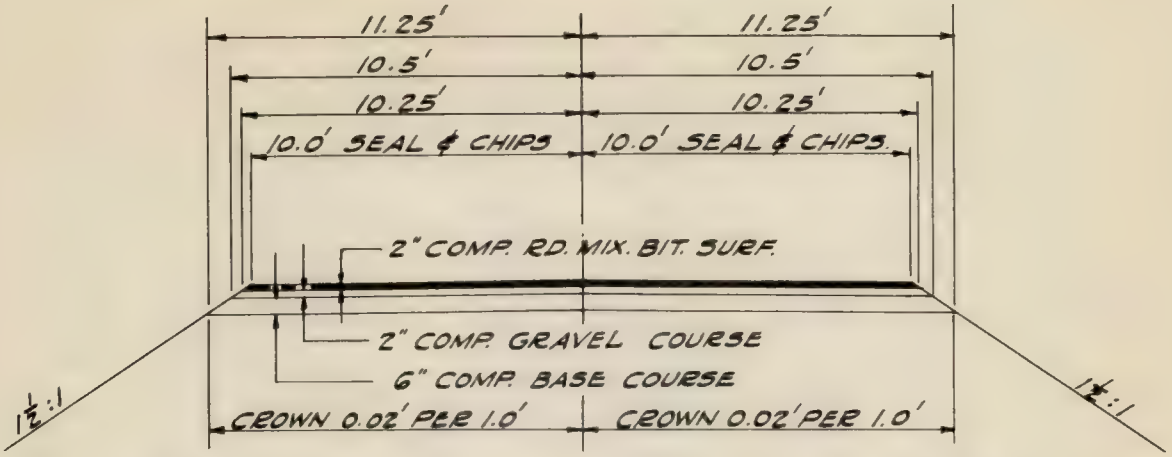
SURFACING FOR BRIDGES & APPROACHES

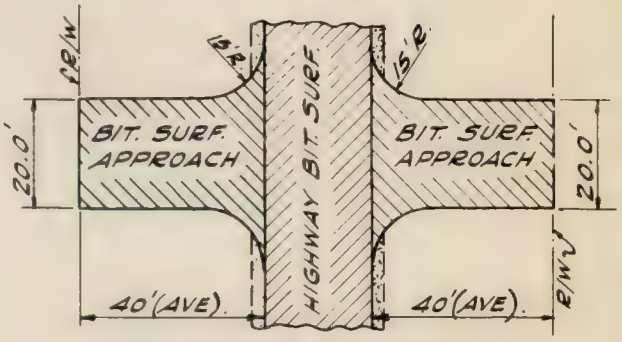
ROAD MIX. BITUMINOUS SURFACE APPROACH



QUANTITIES

ROAD MIX BIT. SURF.
(ONE SIDE ONLY)

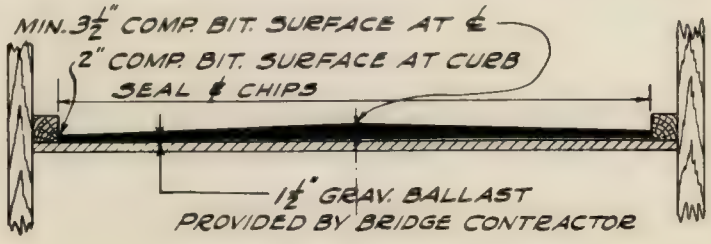
TONS 6" COMP. BASE COURSE	25
TONS 2" COMP. GRAVEL COURSE	8
TONS 2" COMP. TOP COURSE	8
TONS STONE CHIPS	2
GALS. MIX OIL	140
GALS. SEAL OIL	94
SQ. YDS. PROCESSING	100



ADD 20 % FOR COMPACTION ON SUMMARY SHEET.

CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
MIX OIL = 1.4 GAL PER SQ. YD.
SEAL OIL = 0.333 GAL. PER SQ. YD.

ROAD MIX BITUMINOUS SURFACE BRIDGE.



ROAD MIX. BIT. SURF.

BR. RDWAY WIDTH	TONS PER LIN. FT. CHIPS	TONS PER LIN. FT. TOP COURSE	GAL. PER LIN. FT. MIX	GAL. PER LIN. FT. SEAL	SQ. YDS. PER LIN. FT. PROCESSING
24'	0.032	0.291	3.734	0.889	2.667
26'	0.035	0.315	4.045	0.962	2.889
28'	0.037	0.338	4.355	1.036	3.111
30'	0.040	0.362	4.667	1.110	3.333
32'	0.043	0.386	4.978	1.184	3.556

CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
MIX OIL = 1.4 GAL. PER SQ. YD.
SEAL OIL = 0.333 GAL. PER SQ. YD.
ADD 20 % FOR COMPACTION
ON SUMMARY SHEET.

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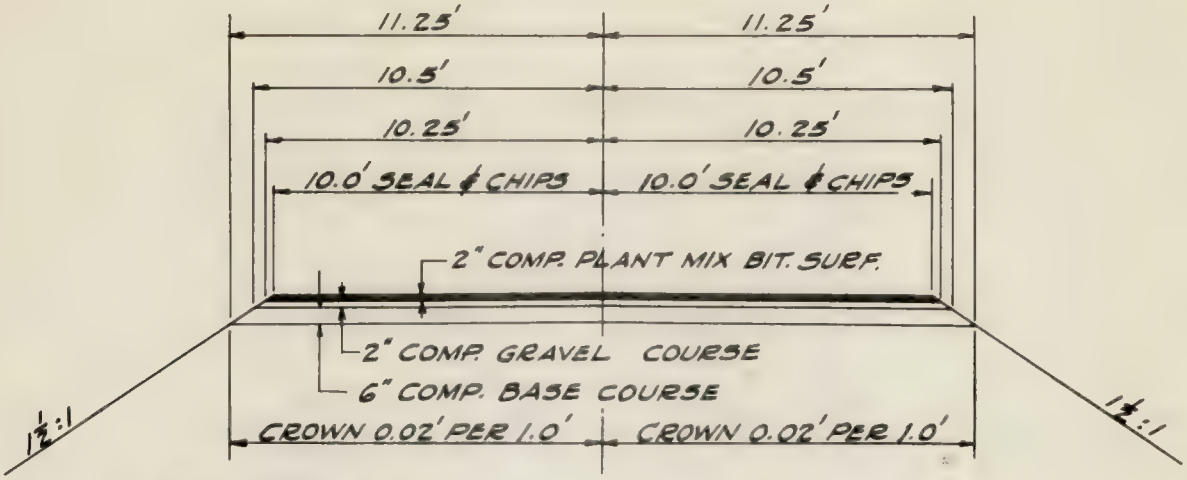
APPROVED - JAN. 1, 1946
ADMINISTRATIVE AID

SURFACING FOR BRIDGES & APPROACHES

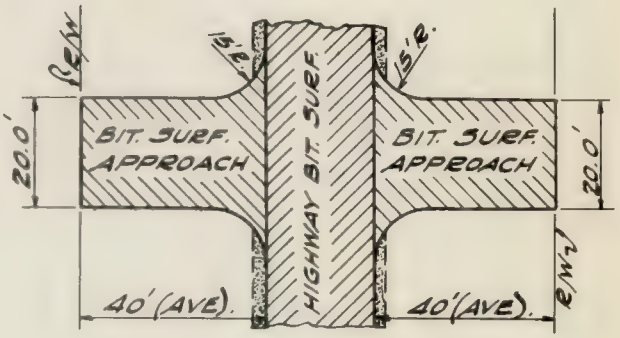
PLANT MIX BITUMINOUS SURFACE APPROACH



QUANTITIES

PLANT MIX BIT. SURF.
(ONE SIDE ONLY)

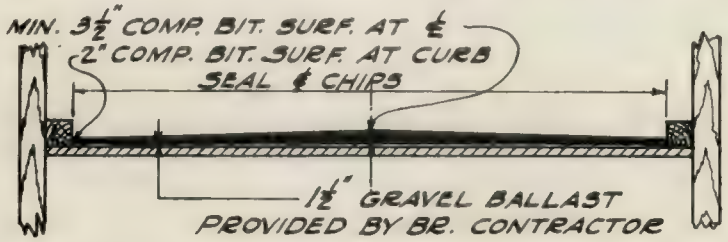
TONS 6" COMP. BASE COURSE	25
TONS 2" COMP. GRAVEL COURSE	8
TONS 2" PLANT MIX.	9
TONS STONE CHIPS	2
GALS. MIX OIL	128
GALS. PRIME OIL	26
GALS. SEAL OIL	34



CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
PLANT MIX = 3021# PER CU. YD.
MIX OIL = 6 % GRAV. WT.
SEAL OIL = 0.333 GAL. PER SQ. YD.

ADD 20 % FOR COMPACTION ON SUMMARY SHEET.

PLANT MIX BITUMINOUS SURFACE BRIDGE



PLANT MIX BIT. SURFACE					
BR. RDWAY WIDTH	TONS PER LIN. FT.		GALLONS PER LIN. FT.		
	CHIPS	PLANT MIX	MIX	SEAL	PRIME
24'	0.032	0.308	4.365	0.889	0.667
26'	0.035	0.334	4.725	0.962	0.722
28'	0.037	0.358	5.070	1.036	0.778
30'	0.040	0.384	5.430	1.110	0.833
32'	0.043	0.409	5.790	1.184	0.889

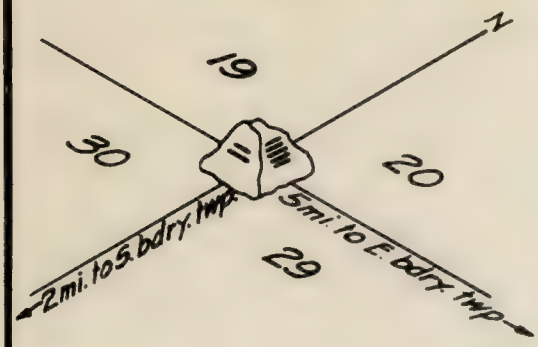
CHIPS = 24# PER SQ. YD.
GRAVEL = 2850# PER CU. YD.
PLANT MIX = 3021# PER CU. YD.
MIX OIL = 6 % GRAV. WT.
SEAL OIL = 0.333 GAL PER SQ. YD.
ADD 20 % FOR COMPACTION ON SUMMARY SHEET.

Montana State Highway Commission

APPROVED - JUN. 1, 1946
ADMINISTRATIVE AID

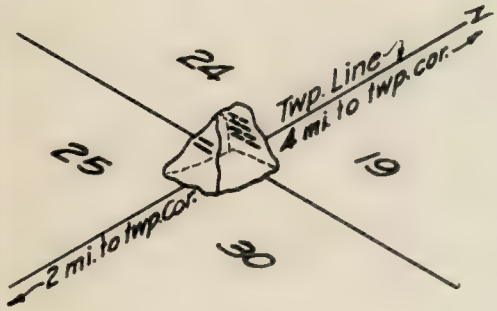
MARKS ON STONE MONUMENTS

Stone corners may be notched on edges, or grooved on faces depending on how stone is set in relation to cardinal points. For convenience, illustrations below show grooves.



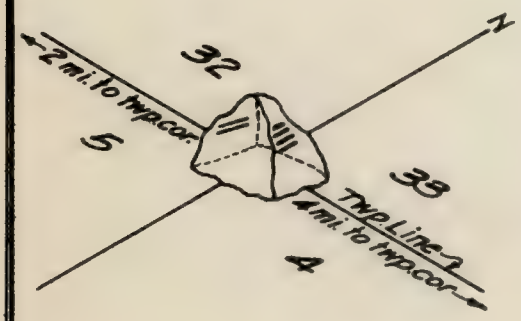
INTERIOR CORNER
COMMON TO FOUR SECTIONS

Number of grooves on East and South faces indicates number of miles from East and South boundaries of the township.



EXTERIOR CORNER
COMMON TO FOUR SECTIONS ON N.&S. TOWNSHIP LINE

Number of grooves on North and South faces indicate number of miles from corresponding township corners.



EXTERIOR CORNER
COMMON TO FOUR SECTIONS ON E.& W. TOWNSHIP LINE

Number of grooves on East and West faces indicates number of miles from corresponding township corners.

Where ties are to be made to land corners, the field party should have a copy of the U.S.G.L.O. notes pertaining to same.

The topography, description of corners and markings, bearing trees and courses contained therein are indispensable for identifying old corners.

For markings used in special cases such as closing corners, meander corners, witness corners, etc., see Manual of Instructions for Survey of Public lands issued for the U.S.G.L.O.

All locators and R/W field men should be familiar with means of identifying corners and also with legal procedure for reestablishing lost and obliterated corners.

Montana State Highway Commission

APPROVED JUN. 1 1946
P.W. Williamson
ADMINISTRATIVE AID

WITNESS MONUMENTS FOR CORNERS

METHODS OF WITNESSING CORNERS WHICH WOULD BE DESTROYED BY HIGHWAY CONSTRUCTION

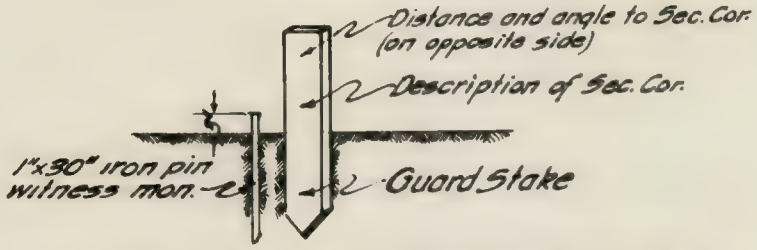
Corners to be witnessed where ever possible by 4 monuments so that original point can be located by intersecting alone. Where the lay of the land or obstructions is such as to prohibit the intersection method, not less than 2 monuments are to be used in tying the corner. The engineer will be expected to exercise his best judgment in selecting the position for witness corners with a view to affording definite and convenient connections from the witness corners to the true point for the monument.

When corner is in fill, cover corner and record as shown in example.

When corner is in cut, reset corner from witness monuments, placing same at least 12 inches below road surface and record depth in notes.

Where ever possible place witness monuments 1 ft. inside R/W lines.

Notes, accompanied by sketch, are to be filed in the office of the County Clerk and Recorder and copy of same to be sent to the office of the Cadastral Engineer in Helena and the general office of the State Highway Commission.



SKETCH SHOWING METHOD OF MARKING & PLACING GUARD STAKES

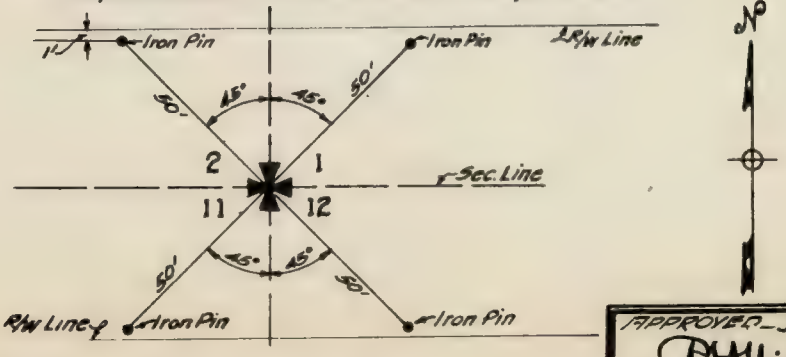
Terry, Mont.
Aug. 2, 1935

I hereby certify that the section corner of Section 1-2-11 and 12, T29N - R45E MPM is covered by highway embankment 4 ft. in depth, that the corner is referenced with iron pins 1" x 30" set at the angles and distances as shown and that guard stakes, giving description of corner, angles and distances as set adjacent to each reference monument.

Tom Smith
Project Engineer
Montana State Highway Comm.

EXAMPLE

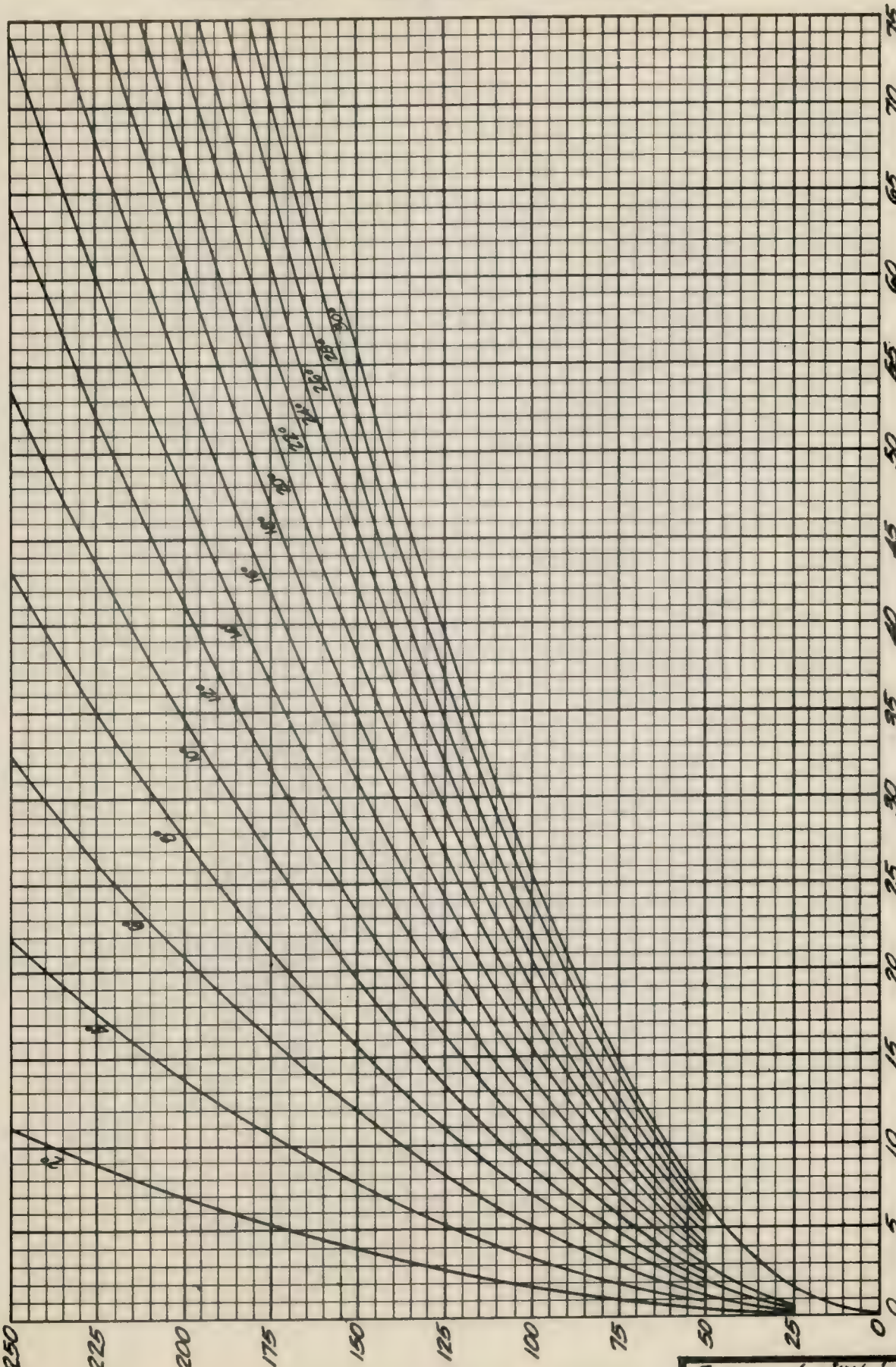
PUBLIC ( ) SURVEY MONUMENT
Corner to Sections 1-2-11-12 T29N-R45E
Referenced by Tom Smith Aug. 2, 1935



APPROVED JUN. 1, 1946
R. A. Hillcoub
ADMINISTRATIVE AID

Montana State Highway Commission

TANGENT OFFSET CHART

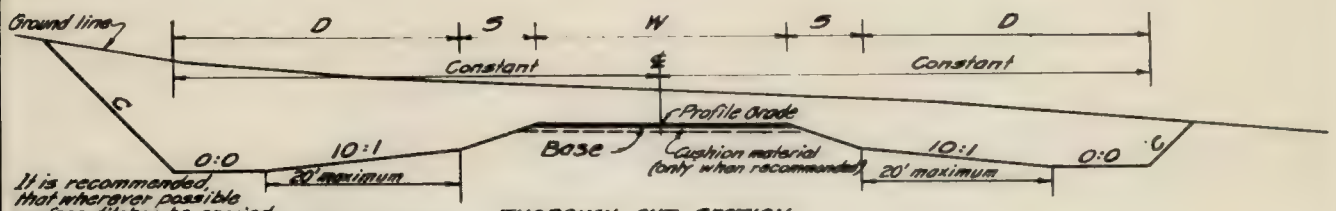


Approved JUN. 1, 1946
ADMINISTRATIVE AID

Montana State Highway Commission.

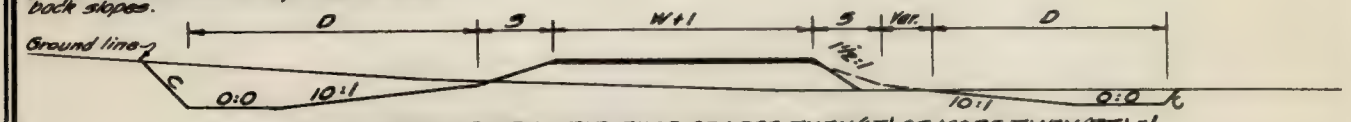
TEMPLATING STANDARDS

Before starting to template a project, consult the typical section to be used. Determine the width of roadway at profile grade(W) and the slope of (S). The roadway is templated with crown on top. Subbase is shown. Cushion material, if recommended, is shown.

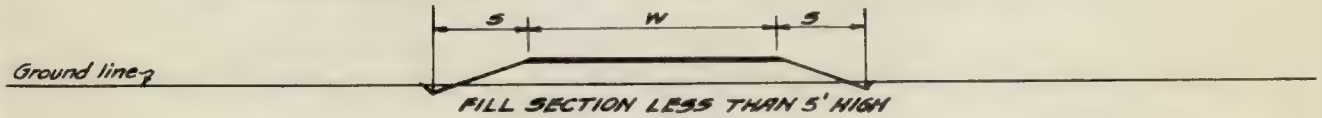


It is recommended, that wherever possible surface ditches be carried on the uphill side of roadway prism to collect & carry water to drains and prevent erosion of back slopes.

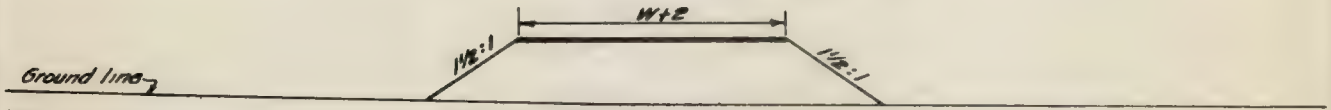
THOROUGH CUT SECTION



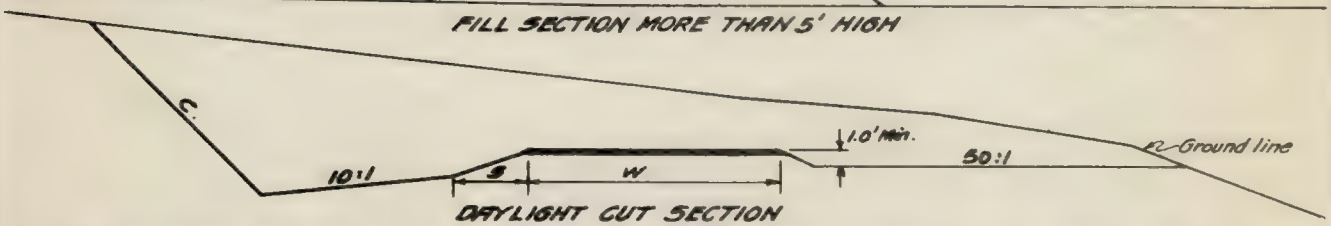
SIDE BORROW SECTION FOR FILLS OF LESS THAN (LT) OR MORE THAN (RT) 5'



FILL SECTION LESS THAN 5' HIGH



FILL SECTION MORE THAN 5' HIGH



DAYLIGHT CUT SECTION

W = Normal width of roadway at profile grade (see typical section to be used). Fills over 5' high are widened 1' on each side of ℄ where 1½:1 slopes are used.

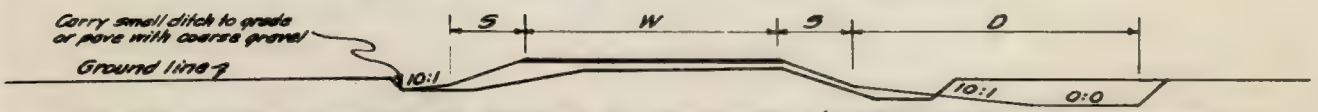
S = Variable width slope depending upon classification of material, drainage, snow conditions and material required to make adjacent fills but must not exceed the limits set on the Typical Sections. Where short sections of fill somewhat in excess of 5' occur adjacent to sections where lesser slopes are used the lesser slope shall be carried through the entire length.

S & C = See Typical Sections for slope of (S), & (C)

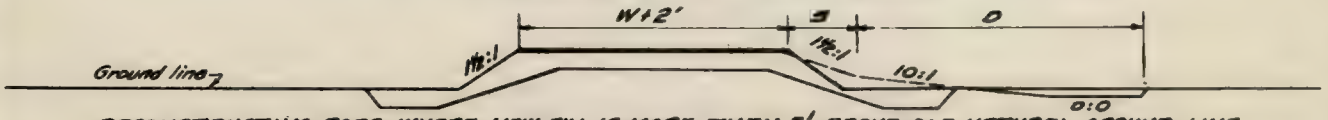
D = Variable borrow ditch - As needed for borrow & drainage up to 20' maximum on the 10:1 slope, any additional width required to be on a 0:0. Widening of ditch should be on snow side where possible. Backslopes are 1:1 unless otherwise recommended where rock excavation is encountered on which up to ¼:1 may be used.

Profile Grade is carried on centerline except on curves where it is carried on the inside shoulder 12' from centerline for 24' Roadway - 15' from centerline for 30' Roadway. All curves are super-elevated and over 3° are widened on the inside edge. See Superelevation and Widening tables. Template transition of superelevation on curve runoff.

PRACTICAL APPLICATIONS OF THE ABOVE STANDARDS



RECONSTRUCTING ROAD WHERE NEW FILL IS LESS THAN 5' ABOVE OLD NATURAL GROUND LINE
(Lt. without side borrow) (Rt. with side borrow)



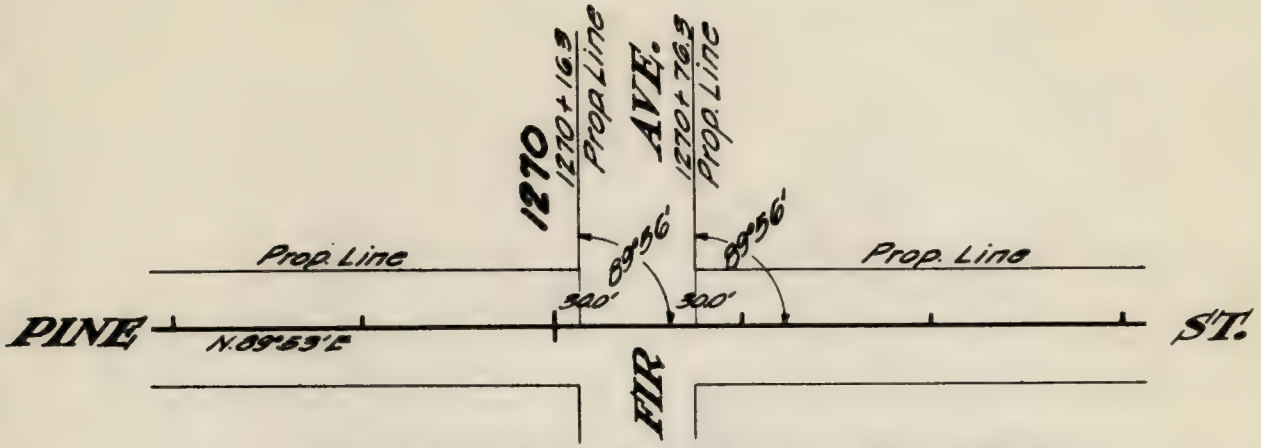
RECONSTRUCTING ROAD WHERE NEW FILL IS MORE THAN 5' ABOVE OLD NATURAL GROUND LINE
(Lt. without side borrow) (Rt. with side borrow)

SECTION SHOWING WHERE HEIGHT OF FILL IS MEASURED TO DETERMINE FILL SLOPE TO BE USED
(Measured at maximum distance of (S)).

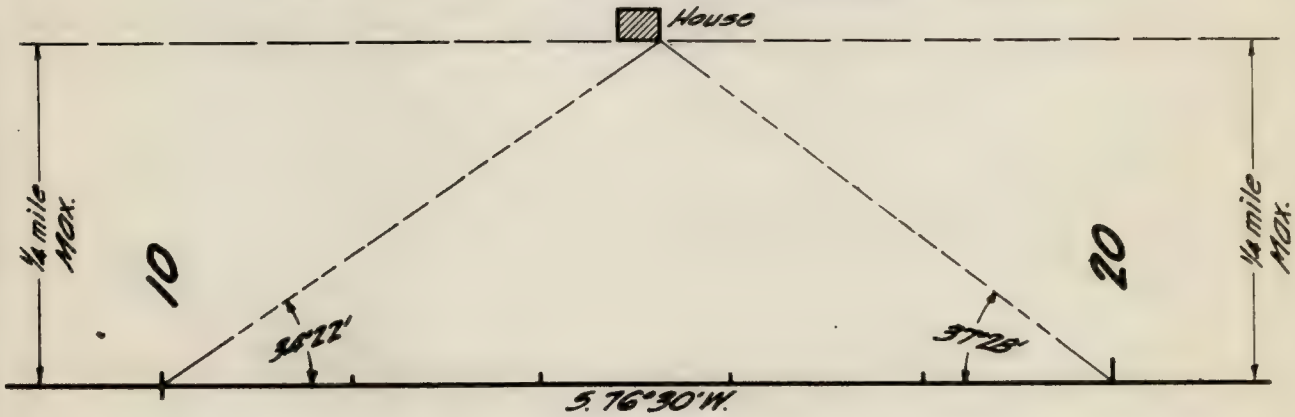
Montana State Highway Commission

APPROVED JUN. 1, 1946
R. A. Willcomb
ADMINISTRATIVE AID

TIE TO PROPERTY LINES

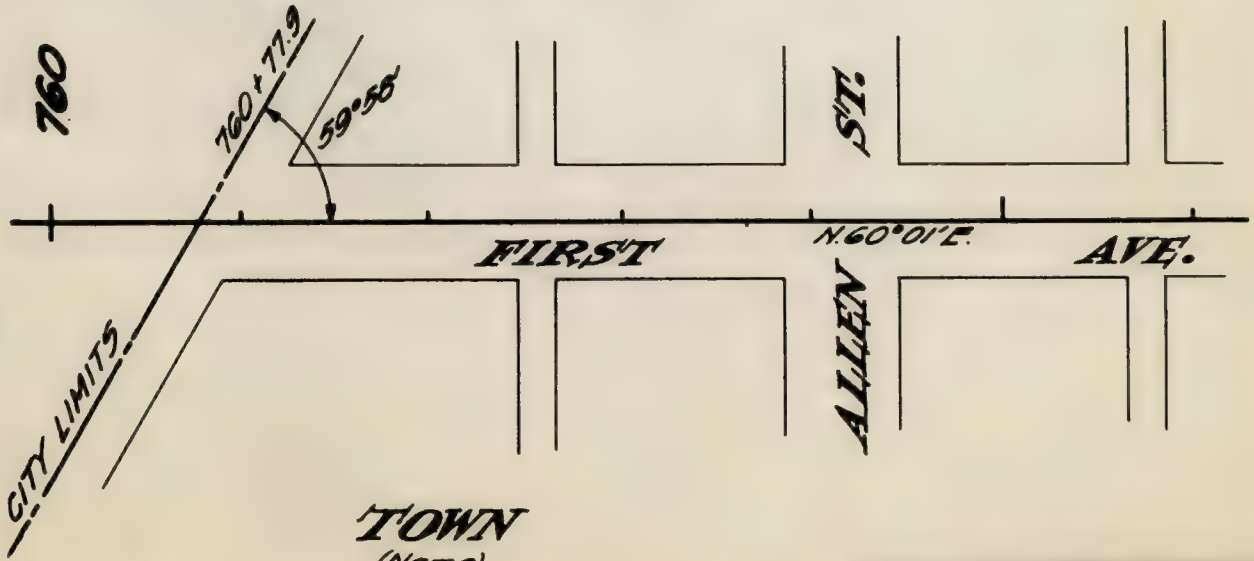


TIE FOR TOPOG. TOO FAR FROM LINE TO CHAIN CONVENIENTLY



TIE TO CITY OR TOWN LIMITS

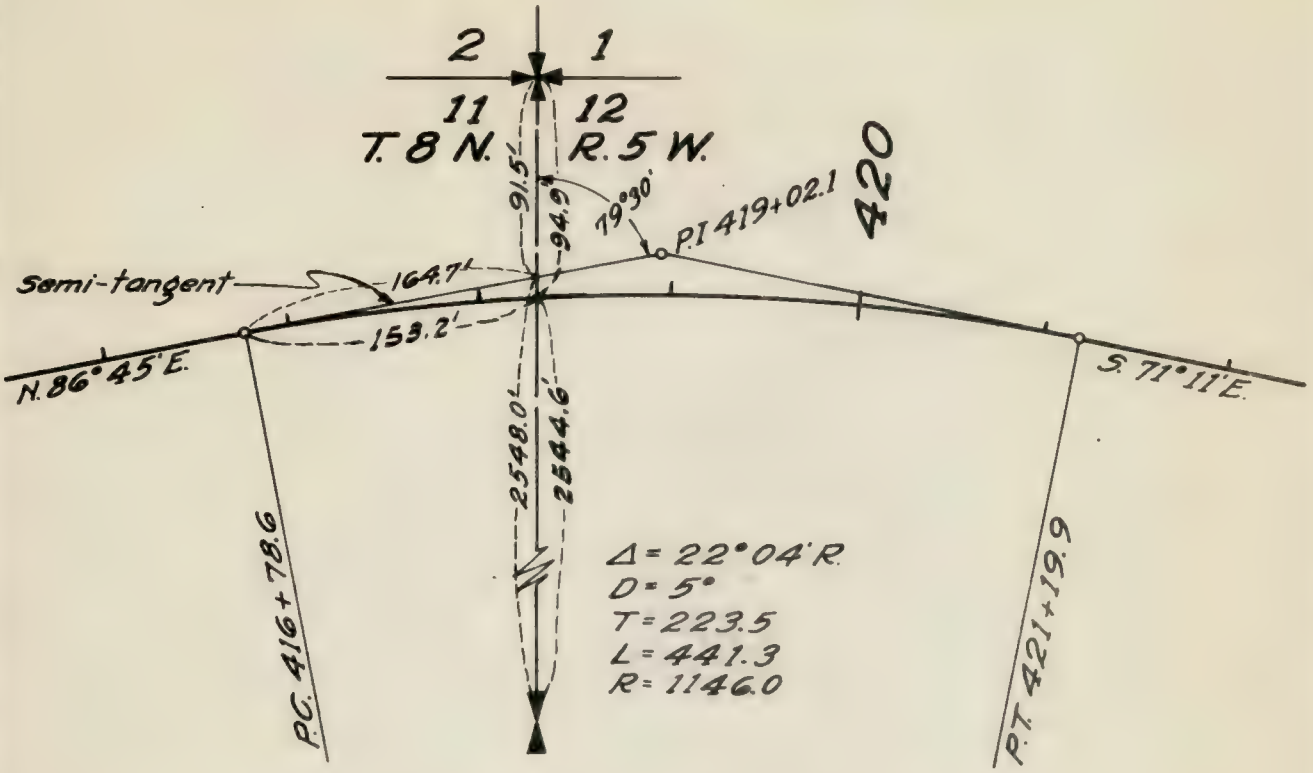
Legal description of city or town to be submitted with location survey notes.



Approved JUN. 1, 1946
C.H. Willcomb
ADMINISTRATIVE AID

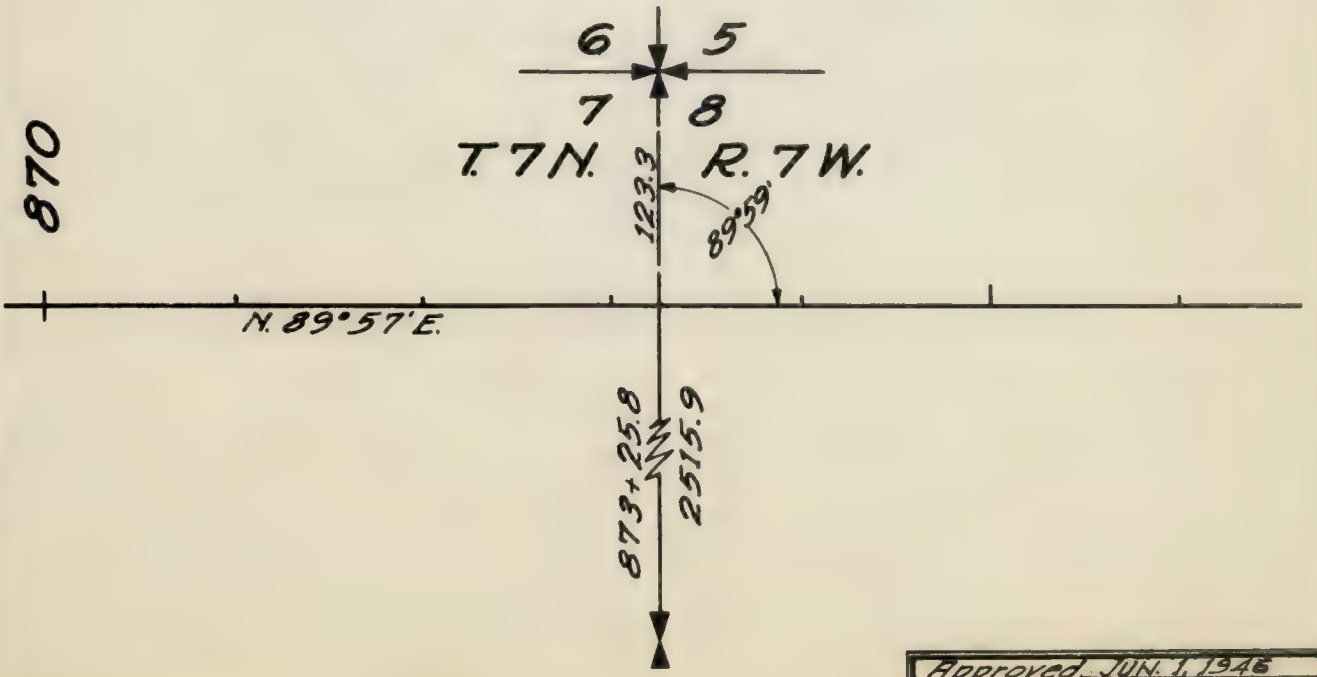
Montana State Highway Commission

TIE TO SECTION LINE ON CURVE



Describe in detail type of corner tied to.

TIE TO SECTION LINE ON TANGENT

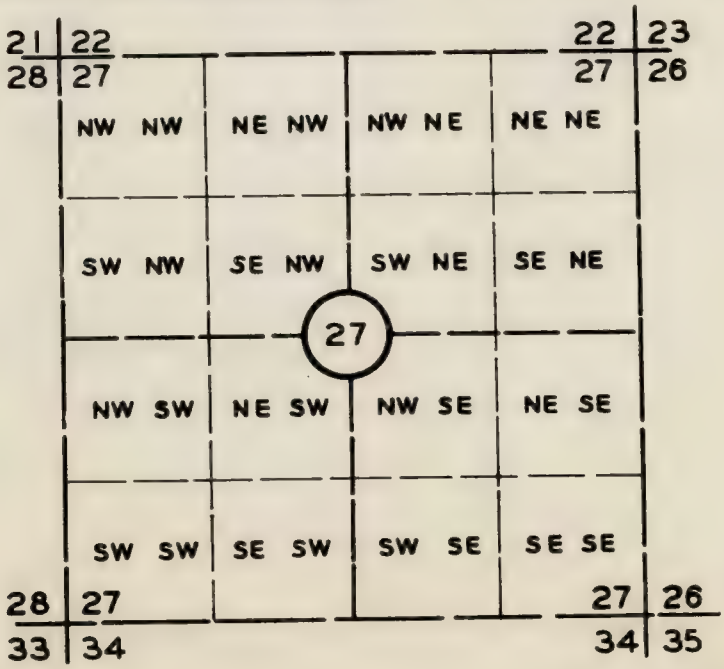


Approved JUN. 1, 1946
R. A. Hillcoat
ADMINISTRATIVE AID

Montana State Highway Commission

TYPICAL SECTION AND TOWNSHIP PLATS

36	31	32	33	34	35	36	31
			T. 36 N.				
			T. 35 N.				
1	6	5	4	3	2	1	6
12	7	8	9	10	11	12	7
13	18	17	16	15	14	13	18
R. 22 E. R. 23 E.						R. 23 E. R. 24 E.	
24	19	20	21	22	23	24	19
25	30	29	28	27	26	25	30
36	31	32	33	34	35	36	31
			T. 35 N.				
			T. 34 N.				
1	6	5	4	3	2	1	6



Montana State Highway Commission.

Approved JUN. 1, 1946.
R. H. Willcomb
ADMINISTRATIVE AID

TABLE FOR COMPUTING YARDAGE

L=LENGTH K=CONSTANT S=SUM OF AREAS

FORMULA - S X K OPPOSITE L=C U. YDS.

L	K	L	K	L	K	L	K	L	K
1	.01852	21	.38889	41	.75926	61	1.12963	81	1.50000
2	.03704	22	.40741	42	.77778	62	1.14815	82	1.51852
3	.05556	23	.42593	43	.79629	63	1.16667	83	1.53704
4	.07407	24	.44444	44	.81481	64	1.18518	84	1.55555
5	.09259	25	.46296	45	.83333	65	1.20370	85	1.57407
6	.11111	26	.48148	46	.85185	66	1.22222	86	1.59259
7	.12963	27	.50000	47	.87037	67	1.24074	87	1.61111
8	.14815	28	.51852	48	.88889	68	1.25926	88	1.62963
9	.16667	29	.53704	49	.90741	69	1.27777	89	1.64815
10	.18519	30	.55555	50	.92593	70	1.29630	90	1.66666
11	.20370	31	.57407	51	.94444	71	1.31481	91	1.68518
12	.22222	32	.59259	52	.96296	72	1.33333	92	1.70370
13	.24074	33	.61111	53	.98148	73	1.35185	93	1.72222
14	.25926	34	.62963	54	1.00000	74	1.37037	94	1.74074
15	.27778	35	.64815	55	1.01852	75	1.38889	95	1.75926
16	.29630	36	.66666	56	1.03704	76	1.40741	96	1.77778
17	.31481	37	.68518	57	1.05555	77	1.42592	97	1.79629
18	.33333	38	.70370	58	1.07407	78	1.44444	98	1.81481
19	.35185	39	.72222	59	1.09259	79	1.46296	99	1.83333
20	.37037	40	.74074	60	1.11111	80	1.48148	100	1.85185

MONTANA STATE HIGHWAY COMMISSION

APPROVED June 1, 1946

J. A. Hilleque

ADMINISTRATIVE AID

REVISED - MARCH 26, 1946

242-Y1

MATERIALS REQUIRED TO MAKE ONE CU. YD. OF RAMMED CONCRETE

MIX	USING 2½" STONE AND UNDER DUST SCREENED OUT.			USING 2½" STONE MOST SMALL STONE SCREENED OUT.			USING 1" STONE AND UNDER DUST SCREENED OUT.			USING ¾" STONE AND UNDER SAND SCREENED OUT		
	BBLS. CEMENT	CU. YDS. SAND	CU. YDS. STONE	BBLS. CEMENT	CU. YDS. SAND	CU. YDS. STONE	BBLS. CEMENT	CU. YDS. SAND	CU. YDS. STONE	BBLS. CEMENT	CU. YDS. SAND	CU. YDS. STONE
1-1½-3	1.90	0.43	0.87	1.96	0.45	0.89	1.85	0.42	0.84	1.71	0.39	0.78
1-2-3	1.73	0.53	0.79	1.78	0.54	0.81	1.70	0.52	0.77	1.54	0.47	0.73
1-2-4	1.48	0.45	0.90	1.53	0.47	0.93	1.46	0.44	0.89	1.34	0.41	0.81
1-2½-4	1.38	0.53	0.84	1.42	0.54	0.87	1.35	0.52	0.82	1.24	0.47	0.75
1-2½-4½	1.29	0.49	0.88	1.33	0.51	0.91	1.27	0.48	0.87	1.16	0.44	0.80
1-2-5	1.29	0.39	0.98	1.33	0.39	1.03	1.27	0.39	0.97	1.17	0.36	0.89
1-2½-5	1.21	0.46	0.92	1.26	0.48	0.96	1.19	0.46	0.91	1.10	0.42	0.83
1-3-5	1.14	0.52	0.87	1.17	0.54	0.89	1.11	0.51	0.85	1.03	0.47	0.78
1-3½-5½	1.02	0.54	0.85	1.06	0.56	0.89	1.00	0.53	0.84	0.92	0.48	0.78
1-3-6	1.02	0.47	0.93	1.06	0.48	0.97	1.01	0.46	0.92	0.92	0.42	0.84
1-3½-6	0.97	0.51	0.89	1.00	0.53	0.92	0.95	0.50	0.87	0.88	0.46	0.80
1-3-7	0.92	0.42	0.98	0.94	0.42	1.05	0.91	0.42	0.97	0.84	0.38	0.89
1-3½-7	0.89	0.47	0.95	0.91	0.49	0.98	0.87	0.47	0.93	0.80	0.43	0.85
1-4-7	0.84	0.51	0.90	0.87	0.53	0.93	0.83	0.51	0.89	0.77	0.47	0.81
1-4-7½	0.81	0.50	0.93	0.84	0.51	0.96	0.80	0.49	0.91	0.73	0.44	0.83
1-4-8	0.78	0.48	0.95	0.81	0.49	0.98	0.77	0.47	0.93	0.71	0.43	0.86

VOLUME OF 1 BBL. PORTLAND CEMENT - 3.8 CU. FT.
LOOSE AVERAGE WEIGHT ABOUT 92 LBS. PER CU. FT.
CINDER CONCRETE AVERAGES 112 LBS PER CU. FT.
CONGLOMERATE, GRAVEL, LIMESTONE, SANDSTONE, TRAP, ETC. WEIGHS FROM 130 TO 150 LBS. PER CU. FT.

ASSUMPTIONS:

The concrete is rammed. Voids in gravel or stone 45%. The mix is based upon a mixture of cement and water in the proper ratio to each other with a dry rodded sand and gravel or stone. The moisture content of sand causes a certain amount of bulking in the volume. Therefore, the kind of sand and its moisture content must be taken into consideration and the proper bulking factor must be multiplied with the sand quantities.

For estimating purposes, the weights of aggregates may be assumed as follows: per cu. yd. of sand, 2800 lbs.; crushed stone, 2450 lbs.; gravel, 2700 lbs.

If accurate weights are required, the actual weights of the aggregates must be obtained from the source of supply. Plain concrete weighs approx. 3900 lbs. per cu. yd., reinforced concrete, approx. 4050 lbs. per cu. yd.

Approved JUN. 1, 1946
R. A. Hillcourt
ADMINISTRATIVE AID

Montana State Highway Commission.